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Official Journal American Congress of Physical Medicine

(Formerly Archives of Physical Therapy)

29th Annual Session

AMERICAN CONGRESS OF PHYSICAL MEDICINE

September 4, 5, 6, 7, 8, 1951

SHIRLEY-SAVOY HOTEL DENVER, COLORADO

VOLUME XXXII JUNE, 1951 NO. 6

American Congress of Physical Medicine

29th Annual

Scientific and Clinical Session

and

Instruction Seminar

September 4, 5, 6, 7 and 8, 1951

Official Headquarters

SHIRLEY-SAVOY HOTEL

Denver, Colorado

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30 NORTH MICHIGAN AVENUE CHICAGO 2, ILLINOIS

INSTRUCTION SEMINAR

In Conjunction with the

29th Annual Scientific and Clinical Session
AMERICAN CONGRESS OF PHYSICAL MEDICINE

September 4, 5, 6 and 7, 1951

SHIRLEY-SAVOY HOTEL **DENVER, COLORADO**

SCHEDULE

Physicians and registered physical and occupational therapists may enroll for either series

TUESDAY MORNING — SEPTEMBER 4	
(A) 10:00-10:50 A.M. Electromyograph, Basic Principles (with demonstration) Golseth	(B) 11:00-11:50 A.M. Electromyography Clinical Aspects Golseth
TUESDAY AFTERNOON — SEPTEMBER 4	
(C) 1:30-2:20 P.M. Functional Anatomy Spine and Trunk	(D) 2:30-3:20 P.M. Functional Anatomy Spine and Trunk
WEDNESDAY MORNING — SEPTEMBER 5	
(E) 8:30-9:20 A.M. Deconditioning in the Invalid and the Aged Taylor	(F) 9:30-10:20 A.M. Deconditioning in the Invalid and the Aged Taylor
THURSDAY MORNING — SEPTEMBER 6	
(G) 8:30-9:20 A.M. Electrical Stimulation — Types of Current and Clinical Physiology Kubicek	(H) 9:30-10:20 A.M. Electrical Stimulation — Types of Current and Clinical Physiology Kubicek
FRIDAY MORNING — SEPTEMBER 7	
(J) 8:30-9:20 A.M. Technique of Scientific Medical Writing Hammond	(K) 9:30-10:20 A.M. Technique of Scientific Medical Writing Hammond

TUESDAY MORNING — SEPTEMBER 4	
(1) 10:00-10:50 A.M. Scoliosis: Causes, Prognosis, Physical Treatment	(2) 11:00-11:50 A.M. Hemiplegia Physical Rehabilitation Deaver
TUESDAY AFTERNOON — SEPTEMBER 4	
(3) 1:30-2:20 P.M. Low Back Pain with Reference to Manipulation Wright	(4) 2:30-3:20 P.M. Post Reduction Treatment of Fractures E. Krusen, Jr.
WEDNESDAY MORNING — SEPTEMBER 5	
(5) 8:30-9:20 A.M. Crutch Walking with Demonstration Deaver	(6) 9:30-10:20 A.M. Physical Treatment of Peripheral Nerve Lesions Kuitert
THURSDAY MORNING — SEPTEMBER 6	
(7) 8:30-9:20 A.M. Treatment of Severely Disabled Rheumatoid Arthritics by Hormonal, Orthopedic and Rehabilitation Procedures Bickel	(8) 9:30-10:20 A.M. Essentials of Muscle Testing (with demonstration) Knapp
FRIDAY MORNING — SEPTEMBER 7	
(9) 8:30-9:20 A.M. Essentials of Muscle Reeducation (with demonstration) Kendell	(10) 9:30-10:20 A.M. Occupational Therapy: Prescription Writing Mead

Note: The Committee on Education of the American Congress of Physical Medicine is in charge of the instruction seminar. It is purposely planned to limit the subjects in any year to a few topics in order to devote enough time to those subjects to give those attending a good review, both from the standpoint of basic knowledge and from the clinical standpoint. Certain groups of these subjects will be repeated every three to five years.

Courses will be offered in two separate groups: One group of ten courses will be offered on basic subjects. A second group of ten courses will present more general and clinical subjects. Physicians and therapists may register for letter or numbered series. Only those therapists registered with the American Registry of Physical Therapists or the American Occupational Therapy Association will be permitted to enroll for the instruction courses. The charge for a single lecture is $2.00, for a full schedule of ten lectures, $15.00.

For full information and application form address

AMERICAN CONGRESS OF PHYSICAL MEDICINE
30 North Michigan Avenue **Chicago 2, Illinois**

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ORIGINAL ARTICLES

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EDITOR OF THE MONTH

GEORGE MORRIS PIERSOL, M.D.
Philadelphia, Pa.

Printed in U.S.A.

29th Annual Session

American Congress of Physical Medicine

September 4-8, 1951

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** Reprinted in part J. A. M. A. 146:197 (May 12) 1951.

1. Courses are so arranged that any of the entrance requirements will qualify students for training. a = Graduation from accredited school of nursing; b = Graduation from accredited school of physical education; c = Two years of college with science courses; d = Three years of college with science courses; e = Four years of college with science courses; f = High school graduation.

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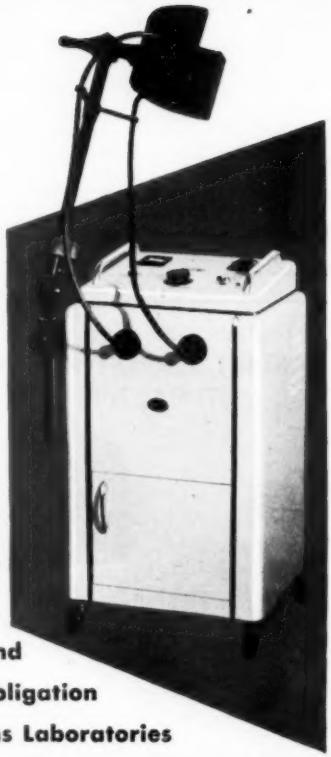

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ELECTROTHERAPY IN EXPERIMENTALLY PRODUCED LESIONS OF PERIPHERAL NERVES *

LEWIS J. POLLOCK, M.D.
ALEX. J. ARIEFF, M.D.
IRVING C. SHERMAN, M.D.
MAURICE SCHILLER, M.D.
ELI TIGAY, M.D.
FREDERICK HILLER, M.D.
ERICH LIEBERT, M.D.
and
GEORGE K. YACORZYNSKI, Ph.D.

CHICAGO, ILL.

Many years ago, electrotherapy was considered to be useful in the treatment of practically all diseases of the nervous system. Somewhat later this attitude was tempered by a wholesome skepticism, which yielded the opinion that some forms of electrotherapy were valuable for some neurologic diseases but that for the most part the observed benefits were due to psychological mechanisms. Only in lesions of the lower motor neuron, either anterior horn cell or its axon, has the therapy withstood the test of clinical observation.

It is generally accepted by clinicians that electrotherapy in the form of stimuli adequate to produce contraction of a paralyzed muscle is useful in the accelerating of the recovery from atrophy of that muscle. It is also considered that electrotherapy delays atrophy and conserves muscle bulk, so that when regeneration of the injured nerve occurs there is good muscle to produce effective contraction. This result is believed to be related to the active contractions produced by the electrical stimuli rather than to any peculiar property of electricity. How this is brought about is unknown.

From the experimental work available, it is not possible to find any uniformity of opinion to support this clinical impression. Although many papers have been written by many investigators, so many dissimilar factors are included in their work that it is difficult to come to any definite conclusions from the results.

Many have described significant retardation in the rate of atrophy and acceleration of the return of the bulk of muscle after injuries of the peripheral nerves. One of the earliest affirmative reports was by Langley and Kato[1] in rabbits. Later this was supported by the work by Gutmann and Guttmann[2] in rabbits. Similar results were reported in rats by Fischer[3], Hines, Thomson and Lazere[4]; Eccles[5]; Solandt, DeLury and Hunter[6]; Wehrmacher, Thomson and Hines[7]; Hines, Melville and Wehrmacher[8]; Kosman,

* From the Department of Nervous and Mental Diseases, Northwestern University Medical School.
* The work described in this paper was carried on under a contract which had, initially the Office of Scientific Research and Development, and subsequently the Office of the Surgeon General, United States Army, as financial sponsors.
* Aided by a grant from the National Foundation for Infantile Paralysis, Inc.
* Drs. Isidore Finkelman and Meyer Brown coptributed to the early part of the experiment and later were commissioned in the United States Navy.

1. Langley, J. N., and Kato, T. S.: J. Physiol. **49**:432, 1914-15.
2. Gutmann, E., and Guttmann, L.: Lancet **1**:169, 1942.
3. Fischer, E.: Am. J. Physiol. **127**:605, 1939.
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5. Eccles, J. C.: J. Physiol. **103**:253, 1944.
6. Solandt, D. Y.; DeLury, D. B., and Hunter, J.: Arch. Neurol. & Psychiat. **49**:802, 1943.
7. Wehrmacher, W. H.; Thomson, J. D., and Hines H. M.: Arch. Phys. Med. **26**:261-266, 1945.
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Osborne and Ivy,[9] and Kosman, Wood and Osborne.[10] There were also affirmative reports in dogs by Kosman, Osborne and Ivy[11] and in man by Shirley Jackson.[12]

A number of investigators were unable to confirm the above observations. Langley[13] himself studied one rabbit and concluded that 21 days of active movement caused by electrical stimulation had no effect upon the loss of weight of a denervated muscle. This was the conclusion of Hartmann and Blatz[14] in a more extensive study in rabbits. Similar results were reported by Chor, Cleveland, Davenport, Dolkart and Beard[15] in monkeys, by Molander, Steinitz and Asher[16] in dogs and by Doupe, Barnes and Kerr[17] in man.

When the literature is analyzed completely, it is found that the experiments have been performed upon both warm- blooded and cold-blooded animals. When warm-blooded animals were used, the species varied — rabbit, rat, dog, monkey and man. The forms of current used for therapy differed from one investigator to another. These have included single instantaneous galvanic stimuli, Leduc current, other forms of periodic galvanic current, faradic current, alternating currents of variable frequencies, and progressive currents. The duration and frequency of treatments varied from 10 discrete stimuli of galvanic current daily to repetitive stimuli for over two hours. The amount of current varied tremendously from that necessary to produce minimal contractions to one so large that anesthesia was necessary to allow it to be used. The amperage of the current frequently was not measured, and if it was it varied widely in different experiments. In some investigations, the extremities were immobilized and in others they were allowed freedom of movement. In most cases, the number of animals was too few for decisive conclusions because there is a large variation in the percentage loss of weight of muscles in different animals in the same species after denervation. Thus it is to be expected that, because of these dissimilar factors, no uniformity of opinion would exist as to the efficacy of electrotherapy upon the recovery of muscles from peripheral nerve lesions.

During the time consumed by our experiment we have also studied the characteristics of the responses of denervated and regenerating muscles to electrical stimuli. From this experience we were able to understand why no single type of current is suited for stimulation equally well throughout denervation and regeneration. The type of electrical stimulus must be suited to the particular characteristics of a muscle at a given time.[18]

During the first few days following denervation, say to 15 days, the denervated muscle still responds to induced currents of lower voltage, the amperage of effective galvanic stimuli is somewhat increased, and, because of polarization changes, repeated unidirectional stimuli soon cease to be effective. The 60 cycle alternating current is effective in slightly greater r.m.s. amperages. The progressive currents usually require somewhat higher amperage, and unless it is alternating polarization changes soon inhibit repeated contractions.

From this time until complete changes of denervation, occupying about 25 days, the voltage of induced current must be increased and that of gal-

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17. Doupe, J.; Barnes, R., and Kerr, A. S.: J. Neurol. & Psychiat. **6**:136, 1943.
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vanic stimuli begins to diminish, but polarization changes continue. There is a necessary increase in the r.m.s. amperage for effective stimulation by 60 cycle alternating current, and marked polarization is present when stimulation by progressive currents is used.

When the characteristics of complete denervation are present from 35 to about 60 days, faradic stimulation and 60 cycle alternating current require still greater amperage; galvanic stimuli, very little amperage, much less than in the normal muscle, and both unidirectional and particularly alternating progressive currents require low amperage for adequate stimuli. Once the electrical signs of regeneration appear, the progressive current becomes useless, both because of the very marked increase of necessary amperage and also because of marked polarization changes by virtue of which continued stimuli become ineffective. Faradic stimulation still requires high voltage, as does 60 cycle alternating current Galvanic stimulation is produced by considerably increased amperage, and polarization changes are present. Under certain conditions, such as when all, and not only some, of the muscles of an extremity are paralyzed, 60 cycle alternating current may be used for treatment, and when the direction of the interrupted galvanic current is reversed on alternate stimuli it may be efficiently used at this time. When only some of the muscles of an extremity are paralyzed, as for example, for a section of only the tibial or the peroneal nerve, spread of current to the normal muscle results in so marked a contraction of this muscle that one cannot determine the amount of contraction occurring in the paralyzed one. Although it is true that the denervated muscle responds to galvanic stimuli of very small amperage when such a muscle is included between electrodes placed beyond its border, the contraction is relatively weak; and, if the amperage is increased, the strong contraction of the normal muscle masks the weak one of the paralyzed muscle. In general, all forms of tetanizing currents — faradic, alternating, rapidly interrupted galvanic — are at times associated with spread to muscles other than those which are designed to be treated during much of the time after suture of a nerve.

Plan of Experiment

This communication deals with the effect of electrotherapy after section of the peripheral nerves in the leg of cats and rats. The specific items studied were (1) prevention of and recovery from muscle atrophy, (2) contractures, and (3) histological changes in muscles.

The experiment was planned to obtain data regarding the efficacy of treatment upon the retardation of muscle atrophy and facilitation of regeneration of muscle and nerve. The latter was studied by observing the return of motor, sensory and reflex functions and the response to electrical stimuli. A study was made of the effect of electrotherapy upon the development of contractures.

The first part of the experiment was carried out on cats. This was part of a larger study of experimentally produced lesions of peripheral nerves which necessitated the use of the relatively large animal. The muscles and joints are large enough to be treated by massage, passive motion, and electricity selectively. The muscles are more homogeneous than in the rabbit, in which there is more differentiation between red and white muscles. The time necessary for degeneration and regeneration is of sufficient length to permit repeated examination, in contrast to the rat, with its very short time for these processes. Although large enough to meet requirements, the cat is small enough to permit many to be caged within somewhat restricted space,

and, finally, it is a friendly animal, handling of which is less hazardous and more congenial.

Later as the experiment proceeded and our results suggested a contradiction with certain reported experiments in the rat, another project was set up. This included a similar study of the effects of electrotherapy in the rat to see if we could duplicate the experience of others with our method of treatment.

To insure good surgery, most of the operations were performed by Dr. George E. Perret, from the department of neurosurgery, and the remainder by Dr. Richard E. Heller, of the department of general surgery. This insured a constant technique and one not open to the criticism sometimes directed against operations performed by clinicians and physiologists.

To insure a type of acceptable physical therapy, the treatment was administered by Miss Rose Hess and Miss Alma Schoeder, both of whom are members of the American Physical Therapy Association and registrants of the American Registry of Physical Therapists. They administered the treatment with the help of a few assistants directly under their supervision.

The clinical examinations were conducted by members of the department of nervous and mental diseases, who are clinical neurologists. The examinations included general observations and tests of motion, sensation, reflex activities, trophic changes, contractures, ankylosis, and circumference and volume displacement of extremities. Examinations were repeated at intervals of from five to seven days, depending on the time allotted for the particular experiment.

At first, examinations for the response of muscles to electrical stimulation consisted of studies of galvanic and faradic currents; soon afterward, there were added progressive currents of long duration, sinusoidal currents with a range from 1 cycle in 12 seconds to 1 cycle in 1.3 seconds, 20 to 100 cycles per second and 100 to 5,000 cycles per second, respectively. In addition, as the experiment progressed, square wave stimulation was begun and was used to study strength-duration curves.

Type and Technique of Therapy. — The major original experiment was so arranged that the cats received various types of treatment. Some animals received no treatment, in order that we might have a group of controls. Massage and passive movement was the basal treatment to which other treatments were added,since it was feared that if joint changes occurred more frequently in those animals which did not have massage and passive movement a fair comparison could not be made. Thus, for purposes of comparison, there was an untreated group, a group treated with massage and passive movement, which has been reported on in a previous communication,[19] and a group treated with massage, passive movement and electricity.

The electrotherapy consisted of stimulation of the gastrocnemius muscle by periodic application of a 60 cycle alternating current producing prolonged submarginal tetanic contractions. The duration of this treatment was five minutes. The current was allowed to flow for three second intervals and interrupted for two second intervals, so as to get 12 sustained tetanic contractions per minute. In order to time the seconds accurately, a metronome was kept going throughout the treatment at 60 beats per minute. The current strength was adapted in each treatment to get a strong, optimal contraction. The necessary amperage ranged from 4 to 6 milliamperes. We used the bipolar technique, applying one electrode with a diameter of 15 millimeters as closely as possible over the origin of the gastrocnemius muscle

19. Pollock, L. J.; Arieff, A. J.; Sherman, I. C.; Liebert, E.; Yacorzynski, G. K., and Schiller, M.: Arch. Phys. Med. 31:265-276, 1950.

and another electrode of about the same size over the achilles tendon near its insertion into the os calcis.

In all cases treatment was started two weeks after the operation and given daily except Sundays. In those animals with a delayed suture, treatment was started 14 days after the original section and a 14 day rest period followed the secondary operation (60 days after section) before treatment was resumed.

Effect of Electrotherapy on Muscle Atrophy in Experimentally Produced Section and Suture of Sciatic Nerves of Cats

In order to determine accurately the degree of weight loss of the muscles, each specimen was removed immediately after the animal was killed and all were treated the same way. The gastrocnemius muscle was cut at its insertion and origin and separated from the soleus muscle. The plantaris muscle was so adherent to the gastrocnemius that it could not be separated, and these two muscles were called the gastrocnemius complex.

As soon as possible, each muscle complex, both left and right, was weighed in air. At times, some delay was inevitable; to determine the error resulting from this delay, a study was made of this point. It was found that at the end of an hour the muscle suspended in air had lost 6.38 per cent of its original weight.

In a previous publication[19] we showed that the atrophy of muscles of cats whose nerve supply has been sectioned remained unaffected by treatment of the muscles with massage and passive movement. The treated muscles show the same atrophic changes as do the untreated muscles with similar operations. For this reason, cats which receive either no treatment or treatment consisting of massage and passive movement can be combined as controls in determining the effects of electrical treatment.

A total of 127 animals were used in this study. Of this group, 95 animals had primary sutures and 32 had secondary sutures.

Fifty-eight of the 95 animals with primary sutures which received no electrical treatment were used as controls, and 37 animals which were treated with electricity as the experimental group. These animals were killed 30, 60, 90, 120, 150 and 180 days after the operation. The number of controls and experimental animals used at these time intervals is given in table 1. The table also shows the range and average weights of the muscles expressed in grams of the gastrocnemius-plantaris complexes and the tibialis anticus-extensor digitorum complexes of the operated and unoperated muscles. Of these muscle groups, only the gastrocnemius-plantaris complexes on the operated side of the experimental animals received electrical treatment.

The group of 32 animals with delayed sutures consisted of 21 controls and 11 experimental cats. Fourteen of the controls and eight animals receiving electrical treatment were killed after 135 days, and seven controls and three experimental animals, after 180 days.

The muscle complexes which received electrical treatment can be compared with the muscle complexes in the same limb which did not receive electrical treatment. In the experimental animals the gastrocnemius-plantaris complexes received electrical treatment and the tibialis anticus-extensor digitorum complexes did not. Thus, a total of 96 treated and untreated muscle complexes of the same limb were involved in this comparison. Seventy-four of these muscle complexes were in animals with primary sutures and 22 in animals with secondary sutures.

The treated gastrocnemius-plantaris complexes of the experimental animals can also be compared with the untreated gastrocnemius-plantaris complexes of the controls. In this comparison 127 muscle complexes of the animals with primary and secondary sutures are utilized.

The method of covariance was used in analyzing the data. With this method not only the experimental variable consisting of the type of treatment and the number of days of treatment can be taken into consideration but also a correction for the weights of the muscles studied can be made. In this correction the weight of the gastrocnemius-plantaris complexes receiving the electrical treatment on the operated side can be adjusted to the weights of the operated tibialis anticus-extensor digitorum complexes on the same side not receiving electrical treatment, and at the same time to the weights of the normal gastrocnemius-plantaris complexes on the opposite side. The weights of the gastrocnemius-plantaris complexes of the experimental animals are then compared with the weights of the gastrocnemius-plantaris complexes of the controls. Thus, a total of 508 muscles complexes is used of the animals with primary and secondary sutures.

All the above factors can be taken into consideration by analyzing the data as a whole. The F value derived in this way for the cats with primary sutures was 0.39 with 1 and 83 degrees of freedom. The difference between the treated and untreated muscles is not statistically significant and shows that treatment with electricity has no effect on the atrophy of muscles.

TABLE 1. — *Range and Average Weights in Grams of the Left Gastrocnemius (L. G.) and Left Tibialis (L. T.) Muscle Complexes on the Operated Side and the Right Gastrocnemius (R. G.) and Right Tibialis (R. T.) on the Unoperated Side of the Experimental (Those Receiving Electrical Treatment) and the Controls After 30, 60, 90, 150, and 180 Days Following the Operation.*

	Experimental Animals									
	Days After Operation									
	30		60		90		150		180	
	Number of Animals									
	4		6		20		4		3	
	Avg. Wt.	Range	Avg. Wt.	Range	Avg. Wt.	Range	Avg. Wt.	Range	Avg. Wt.	Range
L.G.	7.45	4.97–10.76	12.44	9.36–16.12	14.89	9.34–19.51	19.77	16.72–23.16	17.24	13.32–19.60
L.T.	2.70	1.88– 3.87	3.96	2.73– 4.74	5.65	3.29– 7.60	6.98	5.18– 8.27	6.54	5.20– 7.53
R.G.	17.52	11.82–23.75	24.41	18.77–30.25	22.36	14.78–27.20	26.52	24.21–31.00	20.48	17.22–22.52
R.T.	6.79	4.54– 9.27	8.31	6.64– 9.76	7.84	6.00–10.68	9.03	7.42–10.52	7.57	6.35– 9.18
	Controls									
	Number of Animals									
	12		10		23		10		3	
	Avg. Wt.	Range	Avg. Wt.	Range	Avg. Wt.	Range	Avg. Wt.	Range	Avg. Wt.	Range
L.G.	8.74	3.67–12.91	10.52	6.40–12.25	16.35	12.27–20.10	20.65	10.97–27.71	25.52	19.44–28.82
L.T.	2.98	1.45– 4.21	3.56	3.10– 4.08	5.80	4.39– 7.80	7.13	4.52–10.01	10.17	8.30–11.79
R.G.	18.04	7.00–26.52	22.49	18.26–26.84	25.24	17.03–32.51	26.59	17.42–34.32	30.89	22.76–37.98
R.T.	7.34	3.80–14.32	7.90	6.71– 9.52	8.72	6.58–10.87	8.68	5.69–11.18	10.78	7.98–12.59

Analysis of the muscles of animals with delayed sutures yielded the same results.

Effect of Electrotherapy Upon Recovery from Muscle Atrophy in Primary Suture of the Peroneal Nerve in the Cat.

Since in the experiment upon the cat the treatment consisted of contractions produced by 60 cycle alternating current and in the case of Gutmann and Guttmann in the rabbit the contractions were produced by repetitive galvanic stimuli, we decided to repeat their experiment, using the cat as the experimental animal and repetitive galvanic stimuli to produce contractions. Gutmann and Guttmann carried out electrical exercise daily for 15 to 20 minutes at a current strength of 4 to 6 milliamperes. During the 20 minutes of treatment about 500 to 600 single contractions of the muscles were produced.

For our experiment a galvanic current stimulator was used which delivered 40 current impulses of rectangular wave form per minute, the duration of each impulse being 0.5 second, and the interval between successive impulses being 1 second. At each succeeding stimulus the direction of current was reversed to prevent polarization changes. As a result of this procedure, 300 cathodal closing contractions and 300 anodal closing contractions were elicited during the treatment period.

During the fifteen minutes of treatment, 600 submaximal contractions were obtained, the value of current being adjusted as needed to maintain the desired end-point.

Both peroneal nerves of 12 cats were severed and immediately sutured. Electrotherapy was begun 14 days following operation and continued daily until the end of the experiment, 80 days later.

The animals were killed on the eightieth day for the reason that we wished to avoid too long-continued exercise from voluntary motion, which at the ninetieth day would have recovered fairly well.

A comparison of the percentage loss of tibialis muscle complex of the untreated extremity with that of the treated one shows that in two animals the tibialis muscle complex was heavier on the treated side by 9 and 17%. On the other hand, the tibialis muscle complex on the treated side was lighter than that on the untreated side in 10 animals, by percentages ranging from 0.3 to 10%.

Employing the same amount of "electrical exercise" upon denervated and regenerating tibialis muscle complex produced by the same form of electrical stimuli as was used by Gutmann and Guttmann in the rabbit, we were unable to confirm their results in the cat. There was no retardation of atrophy nor facilitation of return to normal bulk of muscle when it was treated by electrical stimuli.

Effect of Electrotherapy Upon Denervation Atrophy of Muscle in the Rat.

The challenge afforded by the experiments of others using the rat suggested to us that there may be a species difference in the rat. This impression was reinforced by the fact that in the rat the period of time necessary for complete denervation of the muscle is very short, 14 days, and the period of time necessary for regeneration is also very short, 28 days.

To test this, an experiment was devised wherein we were to attempt to treat the denervated gastrocnemius muscle of the rat with electrical stimuli producing submaximal contractions comparable to those we had obtained in the experiments upon cats. These contractions were to be as strong as were possible to obtain without spread of current to other muscles and particularly

not to the trunk or opposite limb. It was expected and found that the current necessary would be far less than in the case of the cat. Ether anesthesia was used, not because the current was unbearable but because the rat does not lend itself to docile behavior during treatment.

Both sciatic nerves were severed in 25 rats. A considerable segment of the distal portion of the nerve was removed to discourage regeneration. Treatment was begun on the day following operation.

The treatment consisted of repetitive stimuli by 60 cycle alternating current. Forty stimuli per minute were administered for 15 minutes. The stimulus lasted 0.4 second. The source of the potential was a 60 cycle alternating line current; the amperage was controlled by a potentiometer. The repetitive stimuli were made possible by a motor-driven circuit breaker. The indifferent electrode consisted of a copper wire mesh cut into circular pads measuring 5 cm. in diameter and covered with chamois skin. This was applied to the abdomen. The active electrode, consisting of a strip of chamois skin 8 mm. wide, encircled the ankle and was connected to one lead by a clip. Both electrodes were moistened with isotonic salt solution. The amperage was read on a milliammeter, the full scale deflection of which measured 2 milliamperes.

Results. — Comparison of the weight of the gastrocnemius-plantaris muscle complex of the treated with that of the untreated extremity yielded the data in table 2.

One is immediately impressed by the uniformly greater weight of the muscle complex of the treated extremity. The greater weight likewise is seen to increase as more and more days elapse from the time of section of the nerve. After the fourteenth day the difference between the weight of the treated and of the untreated side, expressed in percentage of gain is not as large as that reported by Fischer and Hines, Thompson and Lazere. It may well be that had we produced more marked tetanic contractions the excess in weight would have been greater. However, we were concerned in comparing the changes in the rat with those we had found in the cat when the conditions of treatment were as similar in the two as we could reproduce.

In contrast to the cat, there was a uniformly greater weight of the muscle complex of the treated extremity. It may, we think, safely be assumed that the failure to find any excess of weight of the muscle complex of the treated extremity in the cat and the finding of excess of weight in the muscle complex of the treated extremity in the rat can be attributed to species difference.

Contractures

Up to 60 days, massage and passive movement combined with electrotherapy for five minutes retards the development of contractures more than passive movement alone, but after 60 days, electrotherapy for 5 or 15 minutes markedly diminishes the facilitation of recovery from contractures brought about by massage and passive movement. Thus, whereas massage and passive movement facilitates recovery from contracture through the period of recovery, electrotherapy has a deleterious effect once regeneration of muscle has begun. In relation to this, it was an interesting observation that among the animals receiving electrotherapy, a greater number showed a persistence of fibrillation. From the standpoint of contractures, if these results are applicable to man, electrotherapy should not be used after that time when neurotization of muscle has been demonstrated by methods of electrodiagnosis.

Histological Studies

From the results of histological studies of muscles it was seen that great variations exist in the histopathological picture in all groups, whether treated or not. Neither the number of cells nor the width of the muscle fibers, nor the general evaluation, gives any indication that the treated group is in any way better than the untreated. It is true that 2 of the cats of the untreated group were worse than any of the cats in any of the other groups. However, 2 cats in the same group were markedly better than most of the other cats. In general, we have gained the impression that all muscles look rather alike. The cross striation seemed to be somewhat better in the electrically treated animals. However, here also such wide variations exist that

TABLE 2. — *Comparative Data on Weights in Grams of Treated and of Untreated Muscle Complexes.*

Pat No.	Days After Section	Weight of Treated Gastrocnemius, Left	Weight of Untreated Gastrocnemius, Right	Per Cent Better on Treated Side
4	30	0.520	0.395	+32%
7	30	0.475	0.365	+30%
19	30	0.725	0.575	+26%
5a	30	0.575	0.455	+26%
14a	30	0.695	0.555	+25%
15	20	0.945	0.770	+22%
18	30	0.710	0.580	+22%
6	21	0.565	0.465	+21%
1	30	0.605	0.505	+20%
2a	30	0.670	0.555	+20%
17	30	0.790	0.670	+18%
9	30	0.430	0.365	+18%
21	30	0.650	0.560	+16%
10	9	1.370	1.175	+16%
12	30	0.450	0.400	+12.5%
2	8	0.805	0.705	+12%
3a	12	1.155	1.275	+10%
3b	30	0.690	0.630	+ 9.5%
10a	30	0.620	0.575	+ 8.0%
6a	18	0.795	0.745	+ 7.0%
15a	18	0.925	0.870	+ 6%
16	30	0.530	0.505	+ 5%
13a	30	0.715	0.685	+ 4.0%
14	13	1.520	1.475	+ 3.0%
20	30	0.670	0.675	— 0.1%

no definite conclusion can be drawn. The general evaluation taking into account the width of muscle fibers, cross striation, and cellular exudate shows that there is no great difference between the various groups. This is rather in contrast to Guttmann's statement that animals treated with electricity showed a muscle which was thicker and histologically better than a muscle which was untreated.

Comment

Although an impression exists among clinicians, neurologists and neurosurgeons that electrotherapy retards atrophy of muscle after denervation and accelerates the recovery from atrophy during regeneration, there is no uniformity of opinion among investigators of experimentally produced lesions in animals.

However, as has been seen in cases of unilateral primary and secondary sutures of the sciatic nerve of the cat at varying days after suture, up to and beyond the time when voluntary motion has returned, there was no statistically significant difference in the percentage loss of weight when animals were untreated or treated by massage and passive movement alone or combined with electrotherapy for 5 or 15 minutes.

Three differences in the experiment may be found in the work reported by others when electrotherapy retarded atrophy and hastened its recovery. These are, first, that in the significant experiments the animal used was the rat; second, that the experiments were bilateral, and, third, that the amount of current used necessitated the use of at least light anesthesia. Since the rate of denervation atrophy is so rapid and the period of regeneration so much shorter in the rat than in the cat, it may well be that we are dealing with a species difference of response.

In our experiments when bilateral denervations were performed, statistically significant, though relatively small, differences were seen between treated and untreated muscles. Despite the fact that these differences did not become greater with increased number of days of treatment, it may be said that when an animal has a bilateral denervation of the sciatic nerves, it is not as active as when only one of these nerves is severed. This lessened activity may explain the small difference in favor of the electrically exercised muscle.

The experiments we have performed were designed to give us information which could be used in relation to the treatment of lower motor neuron lesions in man. If it is necessary for stimulation adequate to retard atrophy to anesthetize man daily, or even more frequently, as suggested by the experiments of Solandt, such a method of treatment is impractical.

In such experiments upon the rat, when the amount of current used was so great as to necessitate anesthesia, the resulting contraction in the rats observed by us, and probably present in the experiments of others, were not limited to the paralyzed muscles; they spread and, in fact, often produced stronger contractions in unparalyzed muscles and, at times, a tetanus of the whole body, particularly the trunk, hindlimbs, and tail.

Not only are there limitations to the use of such relatively strong currents in man, but the currents which are used must be suited to the state of the muscle, whether degenerating, denervated or regenerating. During regeneration, the rheobase is so high at times (20 to 40 milliamperes) that it is either impossible or unwise to use a sufficient amount of current to produce adequate contraction. In fact, it is often the case that physical therapists pass current through a regenerating muscle without producing a contraction and are deluded into thinking that the muscle is being treated.

Conclusions

1. After primary suture of one sciatic nerve in the cat, there is no statistically significant difference in the percentage loss of weight of the gastrocnemius muscle when untreated or treated by massage and passive movement combined with electrotherapy for 5 or 15 minutes, at varying intervals, from 30 to 180 days after operation.

2. The same was true for secondary sutures performed 60 days after section at 135 and 180 days after suture.

3. The same was true for bilateral primary suture of the sciatic nerves at 45 and 75 days after suture.

4. After bilateral denervation after 30, 60, 90, and 120 days, there was

a small but statistically significant larger weight of electrically treated muscles. This superior weight did not increase with time and probably may be explained on the basis of generalized lessening of the activity of the cat.

5. Furthermore, we were unable to confirm the results of Gutmann and Guttmann in the rabbit when, after section and suture of the peroneal nerve of the cat, the tibialis muscle complex was treated by electrical stimuli. There was no retardation of atrophy or facilitation of recovery of the bulk of the muscle.

6. The weight of the denervated gastrocnemius-plantaris complex of an extremity of the rat which was treated by electrical stimulus was uniformly greater than that of the untreated side.

7. The failure to find any statistically significant difference between the weight of treated and of untreated denervated muscles in the cat and the uniform excess of weight of the treated denervated muscle in the rat suggests a species difference in response to electrotherapy.

8. Greater numbers of contractures of greater severity occurred in the normal antagonistic gastrocnemius muscle when an extremity, after peroneal nerve section and suture, was treated by eletrical stimuli. This was also found in the experiment upon the sciatic nerve. The cause for this finding is unknown .

9. The gastrocnemius muscles of the cats examined 90 days after primary suture of the sciatic nerve showed marked variations in the histopathological picture. These variations were present in muscles whether treated or not.

ELECTROMYOGRAPHY IN THE EVALUATION OF THERAPEUTIC MEASURES *

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Observation of the electric potentials produced by muscles affords a relatively new and important technique for the diagnosis of neuromuscular disorders and for the evaluation of therapeutic procedures which might be of value in their treatment. The possibilities and limitations of this new "yardstick," and the determination of its significance, are matters of current, past, and future investigations. Thus far, emphasis has been placed on the use of this procedure for diagnosis. In the light of improved techniques for the determination of electric potentials, it is reasonable to expect further extension of diagnostic investigations of normal and of pathologic nerves and muscles. Jakovlev[1] studied the electric potentials of uterine muscle. He was able to distinguish the patterns of such electrical activity during ovulation and pregnancy. It may well be that muscles in other parts of the body will be examined with this technique, and we may, for example, come to learn more about the action of the gastrointestinal and urinary tracts.

It is becoming increasingly clear that much of the information gleaned during the course of these diagnostic researches can be utilized for treatment purposes. The fundamental determination that muscular contraction produces such electrical manifestations indicated the possibility of employing this method to learn of the motions produced by a given muscle. This appears to give us the most exact technique now available for the study of kinesiology. Other workers and my colleagues and I have made such studies. Scheib and Arienti[2] determined which muscles are primarily involved during normal walking. Inman and his associates[3] noted the action of the muscles about the shoulder. Investigations were also made by Miles, Mortensen, and Sullivan.[4] We observed the actions of the biceps, deltoid and trapezius muscles in the normal human subject. We learned that the position of the body, the speed with which a motion is performed, and the degree of resistance influence the production of potentials in muscles and also that at the initiation of a movement potentials can appear in the antagonists.[5]

Such exact information concerning muscle actions is helpful for the administration of proper exercises as well as for diagnosis. It can also be utilized for the proper conduct of occupational therapy. We observed, for example, by means of electromyography, that in the use of the bicycle saw for strengthening of the quadriceps it made a difference whether the foot pedal was situated directly under the thigh or in front of it.

The influence of heat and cold was indicated by Feinstein,[6] who stated:

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It is sometimes difficult to elicit fibrillation action potentials in a muscle suspected of being denervated. This activity can frequently be enhanced by warming the tissue by means of radiant heat. It has been shown experimentally that warming increases and cooling decreases fibrillation. Indeed, it is possible actually to inhibit the activity by cooling. The mechanism concerned here is probably variation in tissue metabolism.

If we accept the possibility that heating of a part can increase its blood flow, the changes described by Feinstein may be related to such blood flow changes. Liebesny and Blutstein[7] observed that retardation of blood flow in extensor digitorum muscles by the application of a rubber bandage caused a diminution in the ampltitude of potentials otherwise occurring during their contraction.

The changes in blood flow might also account for the changes in muscle action potentials in human poliomyelitis following neurotripsy, as described by Hodes.[8] He studied the maximal action potentials elicited by percutaneous nerve stimulation in muscles of 20 patients with chronic poliomyelitis before and after the use of the closed manual neurotripsy method of Billig. No electrical activity after neurotripsy was seen in those muscles which yielded no action potentials before treatment. Partially innervated skeletal muscles which were treated showed a reduction in amplitude of electromyograms up to four months postoperatively, gave slightly greater than the control values from four to eight months after treatment, and on the average yielded action potentials 21.5% larger than those in controls eight months on. The changes were statistically significant when compared with control values.

The information secured by means of electromyography can be of quantitative value. The evaluation of the relative power of a muscle in terms of electrical units can be made by the use of an integrating meter, as suggested by Huddleston and his co-workers.[9] Bauwens' procedure for the same purpose consists in the substitution of a nonconductive resistance for the loud speaker.[10] The action current is rectified, and the electrical energy is measured in terms of microamperes. Another method is to measure the amplitude of excursion on a written record and to make comparisons with the amplitude produced by a predetermined microvoltage. These techniques permit a relative measurement of muscle power and can therefore be employed for the evaluation of various procedures. Such information is of particular value in the consideration of exercise. We observed that contraction of a muscle against increased resistance causes the production of increased potentials as more muscle fibers are brought into use. This indicates the value of resistive exercises. Liebesny and Blutstein noted that normal extensor digitorum muscles contracting synchronously with equal effort showed a normal electromyographic pattern with amplitudes of 25 to 40 microvolts. With synchronous contraction of one muscle working against increased resistance and the other against the same resistance as previously, the former muscle exhibited an increase of amplitude to 80 to 100 microvolts, whereas the amplitude of the latter decreased to 10 to 15 microvolts.

These authors state that in cerebral hemiplegia reciprocal contraction of symmetrical muscles takes place in the same way as in healthy muscles and that in poliomyelitis patients, likewise, reciprocal contraction of symmetrical

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9. Huddleston, O. L.; Golseth, J. G.; Marinacci, A. A., and Austin, E.: The Use of Electromyography in the Diagnosis of Neuromuscular Disorders, Arch. Phys. Med. 31:278, 1950.
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muscles is undisturbed. From their studies, they conclude that it seems contraindicated in spastic conditions of the flexors of the forearm to keep the hand in hyperextension by a splint or brace or to perform active or passive exercises up to hyperextension. The phenomenon of reciprocal contraction in spastic muscles appears to indicate that therapeutic measures in spastic paralysis should assure relaxation. Active exercise of spastic paretic muscles should be performed by synchronous contraction of the symmetrical muscles with resistance for the healthy muscles. Liebesny and Blutstein state that spastic muscles should never be allowed to work against resistance.[7]

In their electromyographic analysis of the physiologic components of tremor, Clare and Bishop[11] consider that they saw evidence of physiologic reinforcement in which voluntary activation of one set of muscles may increase the effect of a reflex stimulus to another unrelated muscle. Spread of excitation occurred to antagonists. Muscles not required in a movement may be involved in tetanus when the contraction of the volitionally activated muscles become strong. Synchronization of details of pattern may occur in several muscles. Tension may appear in a volitionally relaxed arm when the opposite arm is voluntarily clenched. Those workers observed that in certain normal subjects, as well as in some pathologic subjects, a sudden spiking tetanus may occur in a muscle not used in a given movement as effort is increased. For example, when the quadriceps is being used to extend the knee, the anterior tibial may suddenly show considerable activity if a strong effort is made. This is probably due not to a stretch reflex but to an overflow from the internuncial pool which supplies the motor neurons of the quadriceps to activate also the anterior tibial through facilitation produced by increased effort. The same picture is often seen in patients with weakness or paralysis due to peripheral nerve lesions, poliomyelitis, or other pathologic conditions.

According to Denny-Brown's[12] interpretation of electromyography, a willed contraction innervates primarily different units from those involved in spinal stretch reflexes and such units are relatively less amenable to spinal inhibitory processes. In fatigue, although willed effect is maintained, the electromyogram shows the late appearance of isolated but repeated large excursions that enable one to infer that larger units are now taking part.

Bauwens[10] noted that in advanced progressive muscular atrophy and anterior poliomyelitis there is a tendency toward synchronization of activity in intact motor units. On fatigue, the motor units drop out one by one, thus producing a decrease in amplitude of the individual diphasic waves and in the frequency.

Other forms of exercise which could be investigated by electromyography include passive motion. Pollock and his group[13] observed the influence of massage and passive motion on the fibrillations occurring in the muscles of the cat after section of the sciatic nerve. They employed visual inspection through a magnifying glass. They concluded that the muscles treated with massage and passive motion show a lower incidence of visually observed fibrillation in degeneration and regeneration and that there seemed to be a suggestion that treatment with massage and passive motion results in a better picture of successful neurotization of the distal segment of a sutured nerve.

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The electromyographic evaluation of manipulation is indicated by Bauwens,[10] who found that a prolapsed disk produces electric activity at rest in muscles supplied by the root or trunk affected by the pressure. It was sometimes possible to record an increase in activity at rest when an appropriate portion of the spine was manipulated.

Electromyography may assist in the evaluation of the influence of some drugs. Feinstein[6] states that a useful method of eliciting fibrillation in clinical work is by the administration of neostigmine and that it is well known that denervated muscle has an increased sensitivity to drugs. Neostigmine acting at the neuromuscular junction presumably prevents the destruction of acetylcholine and so "potentiates" its action. Watkins[14] felt that electromyography is valuable in the evaluation of drug action in spasticity, rigidity, and involuntary motions.

Summary and Conclusion

Electromyography is a useful technique for the investigation of treatments advocated for neuromuscular disorders. It permits a more exact study of kinesiology and a determination of the influence of blood flow on muscle action. Through its use, information can be secured which is of value in the administration of drugs, heat, cold, neurotripsy, manipulation, and occupational therapy, and of exercises applied actively, resistively, passively, synchronously, reciprocally, reflexly, or by reinforcement. It can be employed to study the phenomenon of fatigue. It is reasonable to expect that it will be applied to evaluate other measures and that its diagnostic and research applications will also be extended.

14. Watkins, A. L.: Electromyography in Orthopedics, J. Bone & Joint Surg. **31-A**:922, 1949.

THE EFFECT OF A SHORT PERIOD OF STRENUOUS EXERCISE ON HEMOCONCENTRATION *

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A means of evaluating competence for physical exercise on an objective basis would be an important tool in studying convalescence, training, and rehabilitation procedures. Unfortunately, tests of "physical fitness" available at present all depend to some extent on emotional vasomotor factors or on the motivation of the subject to carry on an arduous piece of work. Thus they often fail to evaluate properly the physical component in "physical fitness" that we designate as physical competence.

The plasma volume has been observed regularly to decrease in response to a short period of exercise, but the amount of this hemoconcentration is quite variable from subject to subject and has not been correlated with other variables.[1] Unlike the changes in dogs and cats, the increase in hematocrit values after exercise in humans is due to this diminution of plasma and not to release of blood cells from depots.[1c, d]

It seemed possible that if this water shift were a manifestation of some form of adaptation to exercise, the degree of hemoconcentration might bear a relationship to the ability to carry on exercise. Since hemoconcentration occurs with relatively mild exercise, a test depending on hemoconcentration might be devised which would be nearly independent of motivation of the subjects.

The general plan of the study followed two approaches to attempt to relate the hemoconcentration of exercise to the physical competence of the subjects. First, several of the better-existing criteria, such as blood lactate and pulse rate, were measured coincidentally with the indices of hemoconcentration (plasma protein and hematocrit). Secondly, our subjects were chosen in two groups of known contrasting capacity for performance. One group consisted of college runners in the peak of training; the other included nonathletic laboratory workers and medical students.

Even if the results did not yield the hoped-for relationship as a tool for future measurements of physical competence, data might well furnish other leads to an understanding of the cause of variations in hemoconcentration or to discover new valid indices of physical capacity.

Methods

The group of athletic subjects consisted of 11 undergraduate students in training for cross country running. None had outstanding record accomplishments, but all were in rigorous training for stamina and speed in running two to four miles.

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* This research was aided by a grant to Columbia University from the Baruch Committee on Physical Medicine and Rehabilitation.

* Read at the Twenty-Eighth Annual Session of the American Congress of Physical Medicine, Boston, Sept. 1, 1950.

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The unselected group was 11 medical students and laboratory workers engaged in no regular athletic program. All were under 40 years of age, mostly under 30. All in both groups were free of obvious physical disease or deformity.

The exercise chosen was the ascent of stairs from the subbasement to the 7th floor, 8 stories' vertical rise, a total of 110 ft. elevation. The stairs were climbed at a rate of one flight every 15 seconds, two minutes total exercise. Each subject came to the laboratory at least one and one-half hours after a meal and rested sitting in a chair for 30 to 40 minutes prior to exercise. During the latter part of the rest period the pulse rate was taken several times to obtain a plateau resting value. At the end of the rest a 6 ml. sample of venous blood was taken without stasis and mixed with heparin. After the exercise the subject again sat and rested. Five blood samples, drawn in the same manner as the resting specimen, were taken at 1, 5, 10, 20, and 40 minutes, respectively, after the termination of the exercise. Pulse rates were measured at the same times.

The blood samples were centrifuged at 3,000 rpm for one hour to determine the hematocrit value. The supernatant plasma was analyzed for total nitrogen by the micro-Kjeldahl apparatus of Keys;[2] for sugar by the adaptation of the Folin-Malmros method described by Horvath and Knehr;[3] for chloride by the method of Keys,[4] and for lactate by the method of Edwards.[5] Values for nitrogen were converted to protein figures by subtracting 25 mg. per 100 cc. for nonprotein nitrogen and then multiplying by the usual factor of 6.25.

The use of plasma protein as a measure of short-term changes in blood volume is justified by the report of Painter, Holmes and Gregersen.[6] The same workers found the hematocrit value less quantitatively related to blood volume changes. The Evans blue dye method would have given absolute estimate of blood volume but would have involved the error reported by Ebert and Stead[7] as due to changes in the optical density of undyed plasma after exercise.

None of the tests was performed in hot weather, and thus excessive sweating was avoided. No smoking, eating, or drinking was allowed during the period of test and observation. The test exercise varied in severity in different subjects from very easy to slightly submaximal.

Results

The marked differences between the groups of subjects are shown clearly by the much greater lactate rise in the nonathletes (fig. 1) and the greater acceleration in pulse rate (fig. 2). These measurements, together with the methods of subject selection, establish that the groups furnish a real contrast in respect to physical competence for heavy muscular work of short duration.

Figure 3 presents in a similar manner the data on changes in plasma protein. The marked variability between individuals is apparent in both groups, as previous workers have reported in unselected subjects. The decrease in plasma volume varies from 5 to nearly 15 per cent of the resting value. However, the curves on the two groups are practically superimposable, both in respect to average values and to degree of individual variation.

If all the subjects are considered together and the plasma protein is plotted against lactate rise in each individual (fig. 4), again the random variability of hemoconcentration is apparent. In fact, no index of hemoconcentration could be found to be related to any index of physical competence in the various individuals.

The data on hematocrit changes, presented in figure 5, also show no difference between the groups. The smaller percentage rise in hematocrit

2. Keys, A.: A Rapid Micro-Kjeldahl Method, J. Biol. Chem. **132**:181 (Jan.) 1940.
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reading is in line with previous observations and is probably due to the fact that the venous hematocrit does not accurately measure changes in hematocrit of the total blood.

Figure 6 presents the negligible changes in serum chloride and serves as a check to show that there was no large loss of hypotonic fluid as in sweating.

The changes in serum sugar are shown in a similar graphic form in

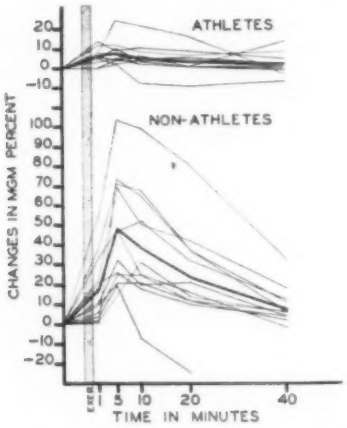

Fig. 1. — Individual (light line) and average (heavy line) changes in serum lactate after two minutes of exercise in contrasting groups of athletes and nonathletes.

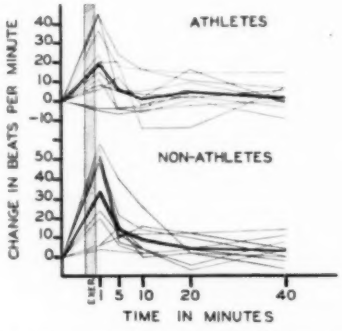

Fig. 2. — Pulse rate acceleration after exercise in group of athletes and group of nonathletes. Light line, individual values; heavy line, group average.

figure 7. In spite of some overlap, the athlete group shows a definitely greater mobilization of sugar into the blood stream than the nonathletes. However, before great significance is placed on this difference, repeat experiments with better control of relation to food ingestion would be necessary. Historically, blood sugar measurements in exercise have been notably va-

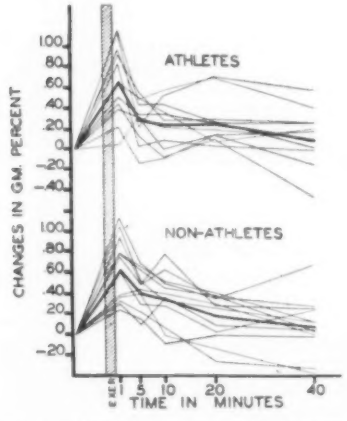

Fig. 3. — Increases in serum protein after exercise in group of athletes and group of nonathletes. Light line, individual values; heavy line, group average values.

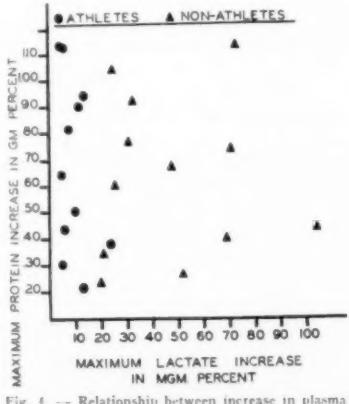

Fig. 4. — Relationship between increase in plasma protein and rise in serum lactate in individuals of both groups of subjects.

riable, probably related to difficulty in controlling the various subtle factors which affect blood sugar.

Comment

Obviously the finding that the decrease in plasma water after exercise does not correlate with physical competence raises the question of other unrecognized variables to explain the marked difference in response from subject to subject.

From repeat observations on three subjects it appears that the type of response is quite uniform in the same subject. This would make it unlikely that our variability from subject to subject was simply a variation from test to test.

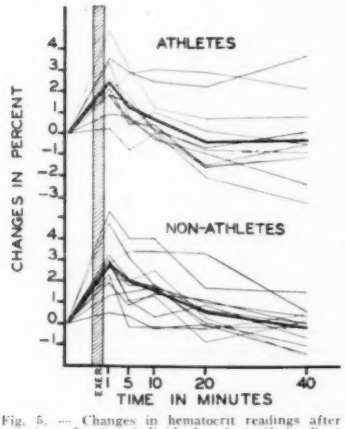

Fig. 5. — Changes in hematocrit readings after exercise, showing individual values (light line) and group average values (heavy line) in contrasting groups of athletes and nonathletes.

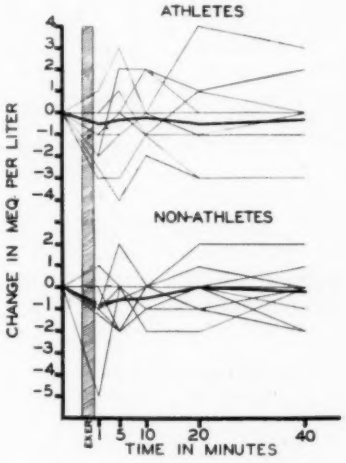

Fig. 6. — Changes in serum chloride after exercise among athletes and nonathletes. Light line, individual values; heavy line, group average values.

To check the possibility that the state of body hydration dictated the response, one subject was retested after 20 hours of fluid deprivation. Although he was thirsty and had a 20 beat higher pulse rate, the rise in plasma protein was the same as when he was normally hydrated

Although other unrecognized variables cannot be excluded, it is likely that the degree of hemoconcentration following exercise is a sort of physiologic fingerprint of the individual. Several such individualistic patterns have been described, such as the general level of sweat chloride and various vasomotor responses.

The purpose or significance of the hemoconcentration of exercise is not clear. From the point of view of hemodynamics it would seem to be a slight disadvantage to the organism in that it requires greater vasomotor adjustment than would be necessary with an unchanged volume of blood. Most likely its significance lies in a greater extracellular volume of the working muscle. Actually the volume lost from the plasma (100 to 500 ml.) could be accounted for solely by increased volume in the lymph channels, but it

would be expected that the return shift would occur more promptly if this were the whole mechanism.

Neither of the questions which led to this work has been answered. A truly objective measure of physical competence for muscular work is still elusive. The mechanisms and significance of the hemoconcentration of exercise must still be guessed at in part. The lack of relationship between

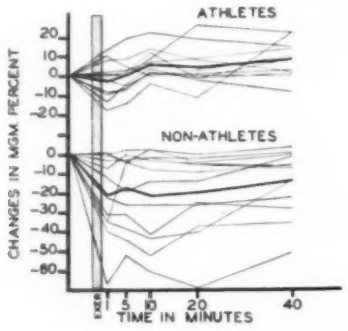

Fig. 7. — Changes in serum sugar after exercise in athletes and nonathletes. Light line, individual values; heavy line, group average values.

the two questions reported in the data above will, it is hoped, stimulate rather than depress interest in the separate problems.

Summary and Conclusions

Two groups of subjects, one of trained athletes, the other of nonathletes were utilized in an attempt to relate the hemoconcentration of exercise to the physical component of physical fitness.

Utilizing serum protein and hematocrit as indices of changes in plasma volume, we found the degree of hemoconcentration to vary markedly among individuals in both groups and to be unrelated in individuals to physical competence as judged by lactate rise and pulse rate acceleration during exercise.

The significance and possible mechanism of this hemoconcentration has been discussed.

We are grateful to the Department of Physical Education, Columbia College, and particularly to Mr. Edgar D. Mason for helping to obtain suitable subjects, and to the subjects themselves for their willing cooperation.

ELECTROPHORETIC STUDIES OF PLASMA AND SERUM PROTEINS IN ANTERIOR POLIOMYELITIS * †

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Of the numerous studies on poliomyelitis, few have been concerned with the plasma or serum proteins of the patients. It has been reported[1] that the albumin-globulin ratio is altered with a decreased albumin and increased globulin fraction occurring during the acute stage of the disease. Kelly and co-workers[2] have observed abnormalities in the beta disturbance of electrophoretic patterns of the serum in poliomyelitis. These investigators, however, did not report values for the protein components of the serum.

For the past few years, we have been engaged in the application of electrophoresis to the analysis of plasma and serum proteins of patients with various diseases. We thought it important to study the protein components of plasma and serum of poliomyelitis patients for comparison with similar data from normal healthy persons.

Experimental

Plasma and serum samples were obtainable from patients with poliomyelitis in the University Hospitals. Samples from normal children were obtained from the Department of Pediatrics; a portion of these has been the subject of a separate communication.[3] Electrophoretic data on plasma and serum from normal adults have been compiled in this investigation and also obtained from publications from this laboratory[4] and others.[5]

The plasma and serum samples were diluted with three volumes of a barbiturate buffer, pH 8.6, ionic strength 0.1, and dialyzed at 2 to 6 C. for three days with daily change of buffer. Electrophoresis was carried out in the Longsworth modification of the Tiselius apparatus using the analytical cell. Mobility measurements and area measurements for each component were made on the descending boundaries of each pattern. Total protein was determined by a biuret method[6] which was calibrated against total nitrogen values obtained by the Kjeldahl method.

Results

Table 1 shows the average percentage composition of the plasma proteins of 103 patients varying in age from 3 to 73 years with an average age of 24 years. The electrophoretic pattern of normal plasma is shown in figure 1 of a previous article[7] and may be compared to a typical pattern of plasma from a patient with poliomyelitis (chart 1).

For purposes of comparison, patients have been divided into groups according to the severity of the disease as follows: (1) those with spinobulbar poliomlyelitis who died; (2) all patients with spinobulbar poliomyelitis; (3) patients exhibiting paralysis; (4) patients exhibiting weakness, and (5) patients with nonparalytic or abortive poliomyelitis.

* From the Departments of Biochemistry and Internal Medicine (Division of Physical Medicine), College of Medicine, State University of Iowa.

* Read at the Twenty-Eighth Annual Session of the American Congress of Physical Medicine, Boston, Sept. 1, 1950.

† Aided in part by a grant from the Institute for the Study of Sedative and Analgesic Drugs.

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2. Kelly, V. C.; Briggs, D. R., and Jensen, R. A.: J. Pediat. 29:423, 1946. Kelly, V. C.; Dorden, Doris; Hall, T. N., and McQuarrie, I.: ibid. 35:752, 1949.
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4. Dryer, R. L.; Paul, W. D., and Routh, J. I.: Proc. Soc. Exp. Biol. & Med. 66:552 1947.
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6. Robinson, H. W., and Hogden, C. G.: J. Biol. Chem. 135:707, 1940.
7. Routh, J. I., and Paul, W. D.: Arch. Phys. Med. 31:511, 1950.

The results indicate that the albumin content of the plasma is decreased in poliomyelitis. In general, this decrease is roughly proportional to the severity of the disease, since patients with the nonparalytic or abortive type have the highest albumin content. The α^1 globulin component increased

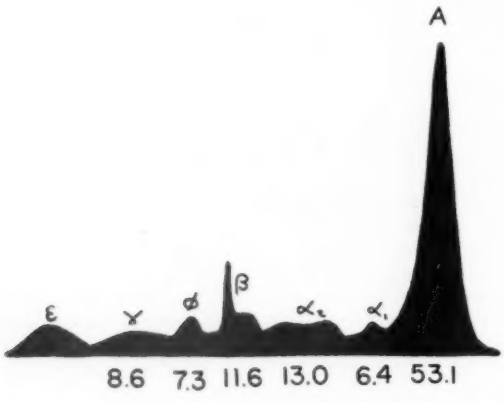

Chart 1. — Typical electrophoretic pattern of plasma from a patient with poliomyelitis.

over normal in all types of poliomyelitis. The α^2 globulin fraction is also increased over normal; and again the increase is roughly proportional to the severity of the disease, since the nonparalytic or abortive type of poliomyelitis shows the lowest value or that closest to normal. Fibrinogen is increased over normal in poliomyelitis and again shows a similar behavior to albumin and α^2 globulin, with the lowest value being found in the group with nonparalytic or abortive type of poliomyelitis.

Probably the most important change in plasma protein components is the γ globulin fraction. In almost all the diseases that have been studied in this laboratory (nephrosis, Laennec's cirrhosis, rheumatoid arthritis, rheumatic fever, and others), the γ globulin component has shown an increase over that of normal plasma and in some instances has doubled or tripled the normal value for this component. In all types of poliomyelitis the γ globulin component is distinctly lower than normal. It is significant that the lowest value of γ globulin occurred in the group of 13 patients who died of spinobulbar poliomyelitis.

The albumin-globulin ratio was definitely decreased in all types of poliomyelitis, as can be seen in table 1. This decrease was roughly proportional to the severity of the disease with the highest ratio occurring in the group with nonparalytic or abortive poliomyelitis. The average total protein of the plasma of 15 typical patients is lower than that of normal healthy persons, although the range of values is fairly wide.

Serum samples were obtained from representative patients with each type of poliomyelitis. Values for the protein components are shown in table 2. A typical electrophoretic pattern of serum from a patient with poliomyelitis is shown in chart 2. The changes in the serum proteins are similar to those observed in the plasma samples. Albumin shows a decrease which is roughly proportional to the severity of the disease, while the α^1 and α^2 and β globulin components are increased over normal.

The γ globulin value in every type of poliomyelitis is equal to or less than the value for normal adults; however, the values are greater than the average for the group of 11 normal children.

TABLE 1. — *Plasma Proteins in Poliomyelitis.*

Type	No. of Patients	Percentage Composition Globulins						Alb./Glob.
		Alb.	α^1	α^2	β	φ	γ	
Spinobulbar (fatal cases)	13	53.7	6.6	12.3	11.7	7.1	8.6	1.16
Spinobulbar (all cases)	26	52.1	6.3	13.5	11.7	7.6	8.8	1.09
With paralysis	20	53.2	6.3	13.5	10.8	7.2	9.0	1.14
With weakness	23	52.2	5.6	13.5	12.3	7.2	9.2	1.09
Nonparalytic, abortive	34	55.1	6.0	12.0	11.3	6.7	8.9	1.23
All patients	103	53.3	6.1	13.0	11.5	7.1	9.0	1.14
Three groups of normal adults	.....	59.0	4.9	8.5	11.9	5.5	10.2	1.44
Normal children								
Age 3-17 yrs.	49	58.4	5.7	10.3	13.2	5.5	9.0	1.41
Average total protein 15 typical patients					6.47 gm./100 ml. (4.90-8.00)			

TABLE 2. — *Serum Proteins in Poliomyelitis*

Type	No. of Patients	Percentage Composition Globulins						Alb./Glob.
		Alb.	α^1	α^2	β	γ′	γ	
Spinobulbar	9	52.6	6.1	13.8	13.0	2.3	12.2	1.11
With paralysis	9	55.5	5.7	12.2	12.2	2.6	11.8	1.25
With weakness	6	57.2	5.5	9.6	12.9	3.3	11.5	1.34
Nonparalytic, abortive	9	56.3	6.0	13.6	10.2	3.4	10.5	1.29
All patients	33	55.2	5.8	12.5	12.1	2.8	11.6	1.23
Normal adults	12	60.4	4.5	10.6	10.0	2.3	12.2	1.53
Normal children								
Age 5-12 yrs.	11	60.6	5.4	9.5	11.8	2.3	10.4	1.54
Average total protein 15 typical patients					6.11 gm./100 ml. (4.90-7.26)			

Serum from normal individuals has a γ′ globulin concentration of from 2 to 4%, with an average around 3%. This component shows normal values in the serum samples from poliomyelitis patients. In an earlier study,[8] we reported that γ′ globulin is increased in Laennec's cirrhosis but was normal in rheumatoid arthritis.[7] Since normal values were obtained in poliomyelitis, this indicates that the liver is probably not involved in this disease.

The albumin-globulin ratio shows a definite decrease from normal, with the lowest value for patients with spinobulbar poliomyelitis. The average total serum protein is also lower than normal and agrees with the results found for total plasma protein.

Comment

The majority of the changes observed in the plasma and serum proteins in poliomyelitis are those which might be predicted from this type of disease. The decrease in albumin and the increase in globulins with a corresponding decrease in the albumin-globulin ratio is commonly encountered in various diseases. While it may be significant that the extent of several of these

8. Franklin, M.; Popper, H.; de la Huerga, J.; Bean, W. B.; Steigmann, F.; Routh, J. I., and Budde, J.: J. Lab. & Clin. Med. 34:1600, 1949.

changes is related to the severity of the disease, the most important alteration is that of the γ globulin component. In most of the diseases studied in this laboratory, an increase in γ globulin has been observed, and it is unusual to find a decrease occurring in poliomyelitis. The only variation from this decrease was found when the serum γ globulin was compared to that of 11 normal children (age 5 to 12 yr.). We have previously shown[3] that the γ globulin component is very low in young children and increased with age.

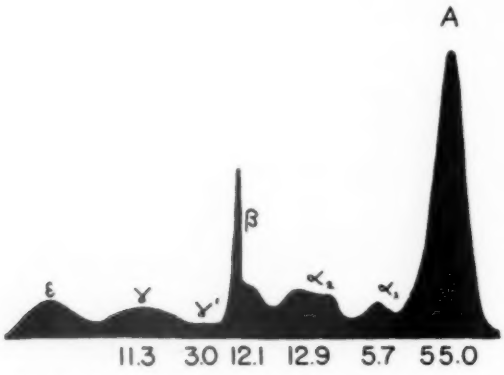

Chart 2. — Typical electrophoretic pattern of serum from a patient with poliomyelitis.

Also the average age of the patient was 24 years, which is close to the age of the normal adults reported in tables 1 and 2. For these reasons, we feel that the decrease in the γ globulin component is a significant finding in poliomyelitis.

To determine whether the lowered γ globulin may be the result of the fever occurring in the early stages and in severe forms of poliomyelitis, the electrophoretic patterns of plasma from several patients receiving artificial fever therapy were studied. In all instances of induced fever, the γ globulin fraction was normal or higher than normal and did not show the decrease observed in poliomyelitis.

Electrophoretic patterns of plasma or serum produced by the Longsworth scanning technique usually exhibit a disturbance in the β globulin component. This disturbance takes the form of a long narrow spike which extends upward from the beta peak. We are in the process of studying the abnormalities in the beta disturbances of electrophoretic patterns in several diseases and will make this the subject of a separate communication. The decrease in the length of the beta spike in the patterns obtained from the plasma and serum samples in poliomyelitis are similar to those observed by Kelly and co-workers.[2] On the other hand, this decrease in the length of the beta spike in patterns from a larger group of normal children and adults occurred about twice as often as that observed by Kelly and co-workers.

Summary

Plasma from 103 patients and serum from 33 patients with poliomyelitis was subjected to electrophoretic analysis.

The albumin decreased, while the α^1 and α^2 globulins and the fibrinogen increased over average values for normal individuals.

The γ′ globulin component was found to be normal in poliomyelitis.

The γ globulin fraction was decreased in all types of poliomyelitis; this has not been a common observation in the various diseases we have studied.

STUDIES ON INCREASED VASOMOTOR TONE IN THE LOWER EXTREMITIES FOLLOWING ANTERIOR POLIOMYELITIS *

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and

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MINNEAPOLIS

It has been reported that after acute anterior poliomyelitis patients may have disturbances in the circulation of their feet and legs,[1] with cyanosis on dependency or in the cold, hyperhidrosis, trophic changes in the skin and nails, swelling of the feet, and frequently hyperesthesia. Venous congestion secondary to muscular paralysis may contribute to the circulatory disturbance. However, it has been observed that the vascular changes are not related directly to the degree of paresis of the extremity[2] and may even occur without evidence of muscular weakness. It has been suggested that these vascular changes are due to increased sympathetic activity after poliomyelitis.[3] Abramson and his co-workers in 1933 studied the circulation of the lower extremities of 27 patients who were in the subacute or chronic stages of poliomyelitis.[1c] They observed that these patients frequently showed a decreased blood flow through the lower extremities when in a cold or cool environment but when the environmental temperature was increased circulation in the extremities increased to equal that of the normal extremities. There was no difference in the reactive hyperemic response of the involved and the normal extremities of these patients. They concluded that the cutaneous vessels of the extremity involved by poliomyelitis are abnormally sensitive to a cold environment, resulting in excessive vasoconstriction. Stenpart[2] in 1948 reported that treatment with a sympathicolytic drug, paravertebral procaine injections or lumbar sympathectomy would provide effective relief from the cold, blue feet and legs following poliomyelitis. Stenpart compared this condition to Reynaud's phenomenon and assumed that it was due to chronic sympathetic hyperactivity.

In the Poliomyelitis Clinic of the University of Minnesota Hospitals, 18 cases of cold feet severe enough to cause discomfort or disability to the pa-

* From the Division of Physical Medicine, University of Minnesota Medical School.

* Read at the Twenty-Eighth Annual Session of the American Congress of Physical Medicine, Boston, Sept. 30, 1950.

1. (*a*) Ogilvie, W. H.: The Place of Operations Upon the Sympathetic System in the Treatment of Poliomyelitis, Proc. Roy. Soc. Med. **26**:129, 1932-1933. (*b*) Telford, E. D., and Stopford, J. S. B.: Some Experiences of Sympathectomy in Anterior Poliomyelitis, Brit. J. Med. **2**:770, 1933. (*c*) White, J. C., and Smithwick, R. H.: The Autonomic Nervous System, ed. 2. New York, the Macmillan Company, p. 208. (*d*) Thomas, A., and Azuriaguerra: Les troubles thermiques et circulatores; l'adipose sous-cutanée de la paralysie infantile, Presse méd. **50**:689 (Nov.) 1942. (*e*) Collins, V. J.; Foster, W. L., and West, W. J.: Vasomotor Disturbances in Poliomyelitis with Special Reference to Treatment with Paravertebral Sympathetic Block, New England J. Med. **236**:694 (May) 1947.

2. Stenpart, K.: Behandling av kalla fotter och ben efter poliomyelit, Nord. med. **38**:1217, 1948. Ogilvie.1a

3. (*a*) Grinker, R. R., and Bucy, P. C.: Neurology, ed. 4. Springfield, Ill., Charles C Thomas, Publisher, 1949, p. 644. (*b*) Telford and Stopford.1b (*c*) White and Smithwick.1c

tient in the cool season of the year have come to our attention (table). Not only the feet but also the legs and thighs up to the hips might become cold enough to cause discomfort. Cyanosis in a mottled pattern was usually found over the feet and legs. Local areas of cyanosis and cold often persisted after hours of exposure to a warm ambient temperature. In most of the patients there was excessive perspiration of the feet associated with the

Sympathetic Dystrophy of Lower Extremities of Patients After Acute Poliomyelitis

Patient	Age	Date of Onset of Poliomyelitis	Date of Onset of Dystrophy	Extent of Paralysis — Right — Thigh	Leg	— Left — Thigh	Leg	Location of Dystrophy Right	Left	Comment
T.S.C.	25	8/46	10/48	60	40	25	8	....	x	Bothered by cold leg but did not wish to try treatment
H.H.	39	1925	?	18	1	33	45	x	x	Relief with D.H.O.
I.T.	37	9/1926	?	32	7	32	8	x	x	Relief with C.C.K.
A.A.	17	9/1946	1/47	38	44	1	0	....	x	Prolonged relief with sympathetic block; relief with D.H.O., 180 1 mg. p.o. b.i.d.
M.L.J.	21	8/1946	9/48	47	18	57	43	x	....	Severe pain in feet in cold weather; relief with Priscoline or C.C.K.
R.F.	30	8/1946	2/50	53	49	60	55	x	....	Froze calf of leg while working outdoors during winter; relief with C.C.K.
C.G.	19	9/1946	1/1947	15	3	2	1	x	x	Cold, cyanotic, numb feet
W.B.	30	8/1946	10/1948	11	19	7	13	x	x	Marked vasospasm of left foot relieved only by procaine block
L.F.	8	8/15/46	3/50	56	52	38	1	x	....	Moderate discomfort
C.W.	16	8/14/46	10/49	20	0	46	48	x	x	Severe cold and sweating
D.H.	24	10/1941	2/1943	....	....	....	....	x	x	Severe cold with marked swelling of feet
A.F.	23	8/1944	3/1945	42	26	33	4	x	x	Painful feet in cold weather
M.M.	20	8/22/44	11/48	18	5	25	6	x	x	Painful feet in cold weather Cold feet at night; relief with Priscoline or C.C.K.
R.B.	21	8/1944	11/44	....	....	....	....	....	x	Painful cold feet
T.C.	31	3/1944	/1944	47	24	20	22	x	x	Painfully cold, stiff, numb feet; relief with Priscoline or C.C.K.
L.P.	22	10/1946	12/1949	0	2	10	14	x	x	Frostbite followed by severe pain and cold; could not wear shoes; relief with C.C.K.
C.A.	12	8/1946	8/1946	60	55	60	55	x	x	Cold from onset; paresis early with recovery of strength
C.R.	17	10/1945	11/1946	60	55	52	32	....	x	Severe pain in foot in winter

Relation between date of onset of poliomyelitis and onset of complaints of symptoms of coldness or excessive sweating of foot indicated in columns 3 and 4. A rough index of the extent of paralysis was obtained by grading 12 muscle groups in the thigh and 11 in the leg according to the system of the National Foundation for Infantile Paralysis: Normal — 5, Good — 4, Fair — 3, Poor — 2, Trace — 1. Summation of grades in thigh and leg indicate relative function. Normal thigh — 60, Normal leg — 55.

coldness. After prolonged exposure to moderately cold temperatures or exposure to severely cold temperature, chronic swelling of the feet and ankles might occur. This was usually associated with hyperesthesia of the toes and feet. Many of these patients also had cold, sweating hands.

The severity of the symptoms increased with increasing exposure to cold. Children living in rural areas who must ride a school bus for an hour or more were particularly susceptible to the cold and were unable to keep their feet warm regardless of how they dressed. Likewise, men working out of doors in the winter time were unable to keep their feet warm. In several

cases there was actual freezing of the feet or legs during exposure under conditions that would be relatively mild for the normal person. All patients reported that during cold weather they had great difficulty in warming their feet in bed at night. Most of them took hot pads to bed and even then lay awake for hours because of discomfort from cold feet and legs.

Most of these patients had some weakness of the lower extremities. However, there was a great variation among these patients in the degree of paresis. Some had severe paresis; some had mild. The degree of vasoconstriction in the feet as indicated by the skin temperatures and the cyanosis did not relate directly to the loss of muscle function. Patients with only moderate weakness showed as much vasoconstriction and had as much difficulty as patients with severe paralysis. On the other hand, other patients with completely flail legs did not have increased sensitivity to cold.

This condition may come on at any time following the acute phase of poliomyelitis. Some patients had evidence of vasoconstriction and hyperhidrosis in the acute phase of poliomyelitis, which persisted into the chronic stage. Other patients had little evidence of circulatory disturbances until they had left the hospital and had been exposed to a cool or cold environment for a period of time. In all cases it appeared that there was a hyperactive response of the sympathetic nervous system to cold, causing marked vasospasm.

This study was undertaken to attempt to develop adequate treatment for patients with painful cold feet after poliomyelitis. Since this is a chronic condition, it was necessary that the treatment be simple and easy to maintain indefinitely.

Methods

Skin temperature responses of patients were studied in a room with temperatures automatically controlled to ±0.25 degree C. All patients had fasted for more than 12 hours. They lay supine on a standard hospital bed dressed in a hospital gown and covered with a sheet from shoulders to lower thighs. Skin temperatures were measured with iron-constantan thermocouples from a Speed-O-Max recorder attached to the first toes, ankles, thighs, and hand. Oral temperature was measured with a mercury thermometer.

It was observed that the response of the patient depended on previous exposure. In cold weather there was more vasoconstriction early in the test and a slower response to applied heat than in warm weather. For this reason vasodilatation was produced at the beginning of the test by exposing the patient to an ambient temperature of 27 C. until a steady state was reached and then cooling the room to 21.5 C. to cause vasoconstriction. After temperatures had stabilized again, hot pads were placed over the anterior and posterior trunk and heat applied through a voltage regulator at a known rate approximately equal to the resting metabolism of the patient.

Patients were studied before and following treatment with D. H. O. 180 (dihydroergocornine), C. C. K. 179[4] (an equal mixture of dihydroergocornine, dihydroergocristine ,and dihydroergokryptine), and Priscoline[5] (2-benzyl-4, 5-imidazoline hydrochloride), or sympathetic nerve block with a 1% solution of procaine hydrochloride. In the normal person the initial temperature of 27 C. caused vasodilatation of the skin of the feet, with equilibrium at approximately room tempertaure. If sweating occurred, there was some evaporative cooling. Vasoconstriction occurred promptly when the room temperature was lowered to 21.5 C., and the skin temperature of the feet fell toward that of the room. Heat applied through the hot pads to the trunk then caused vasodilatation, with a rapid rise of skin temperature to about 30 C.

Results

Chart 1 indicates the type of response of the untreated patient with vasomotor hyperactivity following poliomyelitis. With the room temperature 21.5 C., the toe temperatures fell rapidly to or sometimes below the room

4. D.H.O. 180 and C.C.K. 179 were supplied through the courtesy of Mr. S. M. Fossel, Sandoz Pharmaceuticals, 69-72 Charlton Street, New York 14.
5. Priscoline was supplied through the courtesy of Dr. Jock L. Graeme, Ciba Pharmaceutical Products, Inc., Summit, N. J.

temperature, owing to evaporative cooling. When hot pads were applied, the response of the circulation of the toes and ankles to the heat was very slow. Two hours or more might elapse before there was evidence of vasodilatation in the skin of the toes and ankles. In some patients, even after prolonged heating, there was little vasodilatation. When the patient sat with the legs dependent, there was congestion in the feet, although when the patient lay supine the feet were usually blanched. Mottling of the skin was the usual finding in patients with vasomotor hyperactivity. This mottling persisted after warming of the room or of the torso as well as during exposure to cold. Localized areas of cold persisting during heating were common.

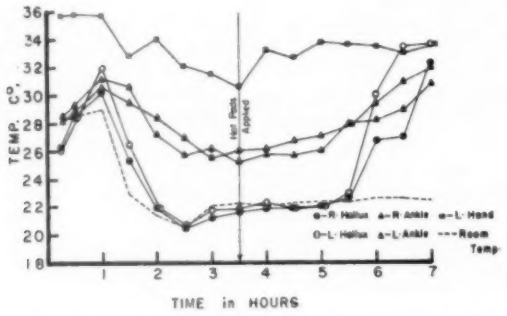

Chart 1 (patient T. C.). — Response of the skin temperatures of a patient with sympathetic hyperactivity following poliomyelitis to changes of ambient temperature and to heat. The patient had severely cold painful feet and legs to the level of the hips in winter and edema of feet and ankles. She observed increased function of legs during treatment with sympathicolytics. Hot pad output, 76 Calories per hour.

Patients treated with the dihydrogenated ergot alkaloids D. H. O. 180

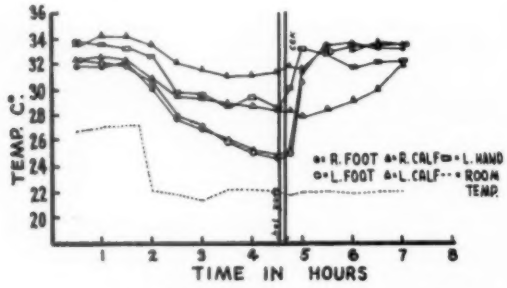

Chart 2 (patient M. J.). — Response of the skin temperatures of a patient with sympathetic hyperactivity following poliomyelitis to C.C.K. 179 and external heating at controlled ambient temperature. The patient had cold feet and legs to the level of the hips in winter. Hot pad output, 76 Calories per hour. The foot temperature is the mean temperature reading from four thermocouples, on the ball of the first and fifth toes, the heel, and the dorsum of the foot. A 2 mg. dose of C.C.K. 179 was given orally at the indicated time.

or C. C. K. 179 while in a steady state at 21.5 C. showed no change of skin temperature in response to the drug alone. However, when the hot pads were applied after administration of 0.3 mg. of the drug intravenously or 2.0 mg. orally, the skin temperature rose rapidly as vasodilatation occurred in the toes and feet (chart 2). The rate of vasodilatation under these conditions

usually was equal to the vasodilatation occurring in the normal subject under similar conditions of ambient temperature and surface heating.

Priscoline given in a dose of 25 mg. intravenously would sometimes cause a temporary partial vasodilatation in the toes or feet at an ambient temperature of 21.5 C. This effect did not persist for more than a few minutes.

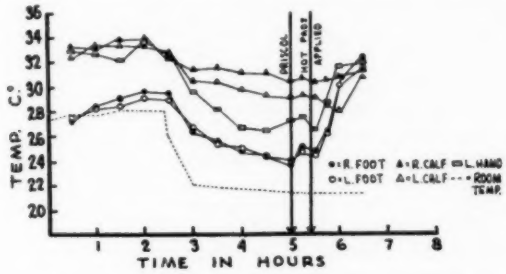

Chart 2 (patient M. J.). — The response of the skin temperature of a patient with sympathetic hyperactivity following poliomyelitis to Priscoline and external heating at a controlled ambient temperature. Hot pad output, 76 Calories per hour. The foot temperature is mean temperature reading from four thermocouples, on the ball of first and fifth toes, the heel, and the dorsum of foot. Priscoline, 18.5 mg., was injected intravenously at the indicated time.

After heating of the torso, reflex vasodilatation of the feet would occur rapidly (chart 3). Priscoline 25 mg. orally, likewise was effective in augmenting vasodilatation in the toes when heat was applied to the torso.

One patient with severe vasoconstriction in the left foot with associated cyanosis, pain, and swelling of the foot was treated by a series of procaine blocks of the left lumbar sympathetic chain. Immediately after the first block, the skin temperature of the left foot and leg increased to that of the opposite side. Swelling and pain in the foot was relieved within a few days. The effect lasted for 10 days. Another block at that time was effective for three weeks. Thereafter the patient was placed on a regime of 1.0 mg. of D. H. O. 180 by mouth twice daily and obtained continuing relief from her symptoms.

After a series of tests in the constant temperature room these patients were followed through the outpatient clinic. D. H. O. 180 or C. C. K. 179, 3 mg. orally four times daily, was found to be effective in preventing cold feet. The patients reported that their feet did not become cold easily and warmed again quickly after exposure to cold. When they went to bed, their feet would stay warm without the need for a hot pad. Quite spontaneously several patients reported that during medication the muscles of the feet and legs were more flexible and could be used more effectively than before treatment. Swelling or hyperesthesia, if present before treatment, disappeared when treatment was instituted. Priscoline, 25 mg. orally, twice or three times daily if tolerated also relieved the vasoconstriction. Certain side reactions accompanied effective medication. Flushing of the face invariably occurred. In some cases development of nervousness and tremor made it impossible to use this drug.

Comment

The phenomenon of sympathetic hyperactivity after poliomyelitis causing vasoconstriction in the feet and legs with resulting coldness, cyanosis, edema, and pain has been recognized, but frequently in clinical practice it is ignored because of the more serious or more dramatic paralyses of the mus-

cles. Nevertheless, this condition constitutes a disability to the patient in whom it occurs. In these patients the cold seasons are times of distress. One of our patients had been unable to wear her shoes for a period of several months prior to treatment because of the swelling and hyperesthesia of her feet. Likewise, these patients reported that their feet and legs appeared to be stiff or wooden in cold weather, aggravating the disabilities due to paresis. The vasoconstriction induced by exposure to cold persisted for hours when the patients entered a warm environment. The discomfort of cold feet frequently caused insomnia and many of these patients took a hot pad to bed with them every night.

The assumption that the disturbances of circulation with cooling, congestion, and cyanosis in the feet and legs of these patients is due mainly to muscle paralysis with loss of the muscle-pump action on the veins would infer there is no effective treatment. Stenpart[2] reported that the vascular disturbance showed no direct correlation with the degree of paralysis. Likewise in our series we observed that there might be day to day variability in the coldness and congestion of two legs which varied considerably in strength. The degree of paralysis from patient to patient likewise did not correlate with the degree of circulatory impairment. One of the patients who had so much vasospasm that he was scarcely able to be outdoors in winter weather did not have severe weakness in either lower extremity (C. R. in the table). Another patient (R. F.), with minimal muscle weakness, froze the calf of his leg while doing chores on his farm. The resulting ulcer persisted without evidence of healing for over a month, until adequate medication with C. C. K. was given. Thereafter the ulcer healed quickly.

The lesions in the spinal cord in cases of poliomyelitis are consistent with these physiological evidences of sympathetic disturbances. Involvement of the sympathetic nuclei in the intermediolateral columns of the cord with destruction both of the internuncial neurons and of the preganglionic sympathetic neurons occurs frequently.[6] Severe lesions of the anterior horns of the spinal cord are always accompanied by lesions of the lateral columns. In some cases there may be diffuse destruction in both areas without severe muscular paresis. Destruction of internuncial cells might result in release of the spinal sympathetic nuclei from the control of higher centers. With release from inhibition, the sympathetic neurons show an excessive response to stimuli from other sources. The sympathetic reflexes are exaggerated. Nerve impulses from any origin impinging on the sympathetics result in increased sympathetic activity and vasoconstriction. It was observed during the acute experiments in the constant temperature room that when patients were under emotional stress the vasospasticity would increase and treatment would be less effective than during periods of emotional calm. An excellent example of this was seen in the case of a patient who, because of an error in scheduling, arrived for an experiment in the constant temperature room to find that she would have to wait five hours before the test could be carried out. At the time of her test, she showed a marked vasoconstriction which responded neither to the sympathicolytic drugs nor to the subsequent heating. Although she appeared to be emotionally calm, she admitted at the end of the experiment that it had disturbed her to have this disruption of her sceddule. Prior to and subsequent to this time she responded very favorably to any of the sympathicolytic drugs and heating, but with this emotional stress the sympathetic activity was too great to be overcome by these drugs.

6. Rivers, T. M.: Viral and Richettsial Infections of Man. J. B. Lippincott, Philadelphia, 1948, p. 250. Grinker and Bucy.[3a]

This study was carried out to determine effective methods of treating vasospasm of the lower extremities with the least inconvenience to the patient. Procaine blocks were effective in causing vasodilatation of the extremities for a period of days or weeks. However, such treatment is not practical for prolonged periods because it requires frequent visits by the patient to the physician's office. Both the dihydrogenated ergot alkaloids and Priscoline were found to be effective in aiding vasodilatation and obtaining relief from cold feet. Priscoline has certain undesirable side effects, particularly production of nervousness and tremor which makes it undesirable in certain patients. C. C. K. is milder and more prolonged in its action, but it appears to be an effective drug for most patients. It is our impression that the combination of Priscoline and C. C. K. may be more effective than either drug alone. Neither of these drugs completely blocks sympathetic activity. Such complete blocking of sympathetic activity would result in a hypotension which would incapacitate the patient during the period of the blockade. Mild interference with sympathetic activity by these drugs reduced the vasoconstricting response to cold and enhanced the vasodilatating response to heat, so that better circulation was maintained in the feet.

Summary

Hyperactivity of the sympathetic nervous system following anterior poliomyelitis may cause abnormal vasoconstriction in the feet and legs resulting in coldness, cyanosis, swelling, and pain. The sympathetic nervous system appears to be hyperreactive to normal stimuli, particularly cold. Circulation in the feet and legs can be improved by depressing the sympathetic activity. Effective depression of sympathetic activity with relief from the undesirable symptoms was obtained by use of the dihydrogenated ergot alkaloids or Priscoline.

* This study was aided by a grant from Ciba Pharmaceutical Products, Inc., Summit, New Jersey.

THE EFFECT OF MICROWAVE RADIATION ON THE PERIPHERAL PULSE VOLUME, DIGITAL SKIN TEMPERATURE AND DIGITAL BLOOD FLOW IN MAN *

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It has been shown that microwave radiation (2,450 megacycles a second) is an efficient method of heating tissue locally without any apparent systematic reaction.[1] This energy is generated in a continuous wave magnetron oscillator tube and is applied to the patient by means of a coaxial cable and director. Microwave energy has some of the characteristics of light in that it is apparently propagated in straight lines and can be reflected, refracted and absorbed. Because microwave radiation in the assigned frequency band has a wavelength of 12.2 cm. (less than 5 in.) and reflects with little or no loss from highly conductive surfaces it can be controlled, concentrated and directed as required for therapeutic purposes. With use of this apparatus on humans, high temperatures have been recorded deep in the muscles and subcutaneous tissues with only minor elevations of surface temperature. In the human thigh close to the femur, temperatures of 39.8 to 40.6 C. (103.5 to 105.1 F.) have been obtained with minimal skin erythema.[2] No increase in body temperature, oral or rectal, or in heart rate has been seen. No effects in tissue other than the liberation of heat have been observed.[3]

Method

Sixty experiments have been carried out on 16 persons varying in age from 20 to 75. However, 11 of these subjects were less than 30 years of age. There were 13 normal persons, 2 with postpoliomyelitis paraplegia and 1 with scleroderma. There were equal numbers of men and women. The procedure was to have each subject lie quietly for a half-hour with arms bared and shoes and stockings removed. The room temperature variation was kept within 1 degree C. for each procedure, but actual room temperature was varied from 15 to 26.5 C. in this series.

The tests were usually carried out near lunchtime, being about four hours after a meal. Subjects were requested not to smoke prior to the test. The right forearm was heated dorsally over its most muscular part for 30 minutes by means of the microtherm. The microtherm used was a portable microwave diathermy unit, Raytheon Model CMD4, with an output of 125 w. at 2,450 megacycles. Then a 30 to 60 minute follow-up was recorded.

* From the Center for Instruction and Research in Physical Medicine, Graduate School of Medicine, University of Pennsylvania.

* Read at the Twenty-Eighth Annual Session of the American Congress of Physical Medicine, Boston, Sept. 1, 1950.

* Aided by a grant from the National Foundation for Infantile Paralysis, Inc.

1. (*a*) Horvath, S. M.; Miller, R. N., and Hutt, B. K.: The Heating of Human Tissues by Microwave Radiation, Am. J. M. Sc. **216**:139, 1948. (*b*) Richardson, A. W.; Imig, C. J.; Feucht, B., and Hines, H. M.: The Relationship Between Deep Tissue Temperature and Blood Flow During Electromagnetic Radiation, Arch. Phys. Med. **31**:19, 1950. (*c*) Osborne, S. L., and Frederick, J. N.: Microwave Radiations, J. A. M. A. **137**:1036, 1948. (*d*) Leiden, L. M.; Herrick, J. F.; Wakim, K. G., and Krusen, F. H.: Preliminary Studies on the Heating and Circulatory Effects of Microwaves, Arch. Phys. Med. **28**:177, 1947. (*e*) Gersten, J. W.; Wakim, K. G.; Herrick, J. F., and Krusen, F. H.: The Effect of Microwave Diathermy on the Peripheral Circulation and on Tissue Temperatures in Man, ibid. **30**:7, 1949. (*f*) Wakim, K. G.; Herrick, J. F.; Martin, G. M., and Krusen, F. H.: Therapeutic Possibilities of Microwave, J. A. M. A. **139**:989, 1949. (*g*) Krusen, F. H.; Herrick, J. F.; Leiden, L. M., and Wakim, K. G.: Microwave Kymatotherapy: Preliminary Report of Experimental Studies of the Heating Effects of Microwave (Radar) in Living Tissue, Proc. Staff Meet., Mayo Clin. **22**:209, 1947. (*h*) Rae, J. W.; Herrick, J. F.; Wakim, K. G., and Krusen, F. H.: Comparative Study of the Temperatures Produced by Microwave and Shortwave Diathermy, Arch. Phys. Med. **30**:199, 1949.

2. Raytheon Microtherm Acceptable, report of the Council on Physical Medicine, J. A. M. A. **135**: 986, 1947.

3. Daily, L. E.: A Clinical Study of the Results of Exposure of Laboratory Personnel to Radar and High Frequency Radio, U. S. Naval Med. Bull. **41**:1052, 1943.

Skin temperatures were measured on the palmar surface of the distal phalanx of the right and left index finger and the plantar surface of the right great toe. The temperatures were obtained by using copper-constantan skin thermocouples with a modified Brown Electronik Potentiometer, and were recorded automatically in degrees centigrade every two minutes

The pulse volume of the right middle finger and left middle finger was taken together with the blood flow of the right middle finger. Pulse volume was measured by means of a Cambridge plethysmograph and calculated to read as cubic millimeters per 5 cc. of part. Pulse tracings were taken continuously throughout the period of heating and every five minutes in the follow-up.

The blood flow was obtained every five minutes by occlusion plethysmography of the right middle finger and recorded as cubic centimeters per 100 cc. of tissue per minute. The venous outflow of the right middle finger was occluded with a narrow cuff made of rubber dam backed with adhesive. This method was utilized by Dr. Alan C. Burton in 1939,[4] when he correlated digital blood flow with digital temperature and pulse volume. The resulting increase in finger volume was photographed and timed with the Cambridge plethysmograph.

Oral temperature was taken with a standardized clinical thermometer before and after treatment. Heart rate was calculated from the pulse recording.

TABLE 1. — *Number of Subjects Treated With Each Director and at Each Power Output.*

		Right Forearm 2 Inch Distance		
		Directors and No. of Subjects		
% Power	Watts	A	B	C
30	37.5	4	4	7
50	62.5	6	4	8*
70	87.5	6	4*	8*
90	112.5	4	3†	2†

* Burns encountered at these powers.
† Test discontinued in three minutes because of aching, pain or burning.

All three types of directors furnished with the microtherm for the application of the microwave were used. Type A director is a 4 in. hemisphere, and at 2 in. distance the heated area is 6 in. diameter. Type B director is 6 in. across, and the heated area at 2 in. distance is 7½ in. in diameter. Director C, or corner director, heats 8 sq. in. of tissue at 2 in. distance. Power control was set until 30 per cent, 50 per cent, 70

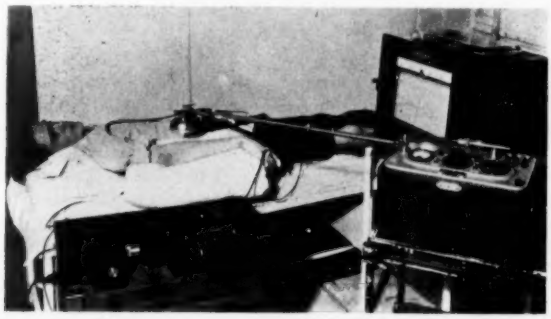

Fig. 1. — Method of experiment showing Cambridge plethysmograph, Brown potentiometer and microwave generator.

per cent, and 90 per cent of power was obtained for the meter reading. This corresponded to 37.5, 62.5, 87.5, and 112.5 W., respectively. In expressing power output, watts has been used instead of percentages of total output. However, it must be kept in mind that this is an approximate figure and that the power output varies with the size and nature of the director (figs. 1 and 2, and table 1).

4. (*a*) Burton, A. C.: The Range of Variability of Blood Flow in the Human Finger and the Vasomotor Regulation of Body Temperature, Am. J. Physiol. **127**:5, 1939; (*b*) Burton, A. C.: The Blood Flow Temperature and Color of the Skin: Am. A. Advancement Sc. **13**:308, 1939.

Results

Twenty experiments have been carried out with the A director, 15 with the B director, and 25 with the C director. There was no significant or consistent change in oral temperature, even with use of 87.5 watts of power for thirty minutes. The pulse rates did not vary except that when 87.5 watts was used with director C, 4 of the subjects showed increases of from 8 to 16 beats a minute.

The environment of the subjects was such that partial vasoconstriction was induced. Thus any effect on peripheral circulation was more easily followed. In all but three procedures, partial or complete vasoconstriction of the subject was observed. These three exceptions were accounted for by the ingestion of food prior to the experiment. The increase in digital pulse volume on both the heated and the unheated arm was observable in less than three minutes in all but seven of the procedures. These seven inconsistencies occurred either when high control pulse volumes were already present or when the power output was so high that pain produced digital vasoconstriction.

Control pulse volumes varied from less than 1 cu. mm. per 5 cc. of part to 11.4 cu. mm. per 5 cc. of part. Increases of digital pulse volume on the treated side varied from 1 to 24.3 cu. mm. per 5 cc. of part. There was no change observed in the volume or frequency of the alpha waves. The alpha waves occurred three to six times per minute (6 to 12 deflections a minute). Their volume varied from 0.3 to 18 cu. mm. per 5 cc. of part. According to Burch,[5] the normal frequency is 2 to 14 deflections a minute for the finger tip and the volume has a mean of 14.5 cu. mm. per 5 cc. of part. Beta waves were observed but were not considered to be of value in our problem. The so-called gamma waves were not searched for in our tracings.

The control blood flow of the right middle finger varied from 9.1 to 41.4 cc. per 100 cc. of tissue per minute and increased in several cases to over 100 cc. per 100 cc. of tissue per minute. In every case the blood flow paralleled the pulse volume.

The digital temperature increase on the heated arm was from 0 to 13.4 degree C. and on the unheated side from 0 to 11.2 degrees. The temperature increase of the right great toe varied from 0 to 5.2 degrees.

Graphs of the results show that the heating was most rapid during the first five minutes, and thereafter, increases were less rapid to maximal. This is in accord with the report of Gersten and associates[1e] that the graph of the increase of blood flow to the duration of exposure to microwave is S-shaped and shows early acceleration of the increase of blood flow followed by retardation. The time of the maximal temperature, pulse volume and blood flow was found at 25 to 30 minutes of heating in 83.3 per cent of the cases. In a few instances maximal values were seen at the end of five minutes and in others during the first five minutes after end of heating (table 2).

In the follow-up rapid diminution of the pulse volume and digital blood flow was seen in 5 to 10 minutes. Sometimes a rebound of the pulse volume and blood flow was seen in 15 to 20 minutes' follow-up. After one-half hour, vasoconstriction was still present in a few instances. The temperature of the fingers paralleled the pulse volume. The toe temperature was not changed significantly, and even when 87.5 watts of power was applied the increase was of the order of 1 to 2 degrees C. and occurred only at the end of 30 minutes of heating or during the follow-up (table 2 and figs. 3, 4 and 5).

5. Burch, Alan C.: A New Sensitive Portable Plethysmograph, Am. Heart J. 33:48, 1947.

The toe temperature of the postpoliomyelitis paraplegics was approximately that of the room temperature and varied like that of normal persons, the only difference being in the initial or control temperature.

When the A director was used, no erythema was observed until 87.5 watts was utilized. Then it was transient in nature and not tender or painful, even when 112.5 watts power output was used. The sensation varied from mildly warm to hot.

However, when the larger hemisphere (B) was used, erythema was seen even with 37.5 watts and lasted up to 24 hours. The sensation varied from warm to burning and aching. In one case the procedure, using 87.5 watts, was discontinued in three minutes. Three attempts were made to use 112.5 watts power, but in each case the experiment was stopped because of burning and throbbing.

TABLE 2. — *Control Values, Increase and Time of Maximum of Digital Temperature, Pulse Volume and Blood Flow.*

T° C.	Control Values Min.	Control Values Max.	Max. Values	Max. Inc.	Time of Max.
R.I.F.	17.9	35.8	36.3	13.4	30 min.
L.I.F.	18.1	34.8	36.0	11.2	30 min.
R.G.T.	17.8	32.1	33.0	5.2	30 min.
Pulse Volume — Cu. Mm/5 Cc Part					
R.M.F.	0.3	10.0	25.9	.....	30 min.
L.M.F.	0.3	11.4	27.6	.....	30 min.
Blood Flow — Cc/100 Cc Tissue/Minute					
R.M.F.	3.0	41.4	150.	.....	30 min.

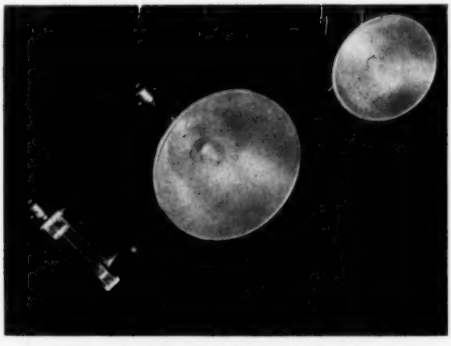

Fig. 2. — Microwave directors A, B and C.

The angle director (C) caused erythema in half the subjects at 37.5 watts power and in all at greater than 37.5 watts. The erythema which is produced persisted for hours.

Three burns were encountered in our series: one with the B director at 87.5 watts, another with the C director at 62.5 watts, and a third with C director at 87.5 watts of power. Two of the burns were small single blisters appearing in 24 hours, taking several weeks for the crust to separate, and healing with a scar. The other burn, occurring in a 61 year old woman, ap-

peared as a large irregular wheal seen immediately at the end of the treatment. There was redness, mild burning, and pain. By the end of the follow-up period the patient was feeling warm all over and the burning sensation

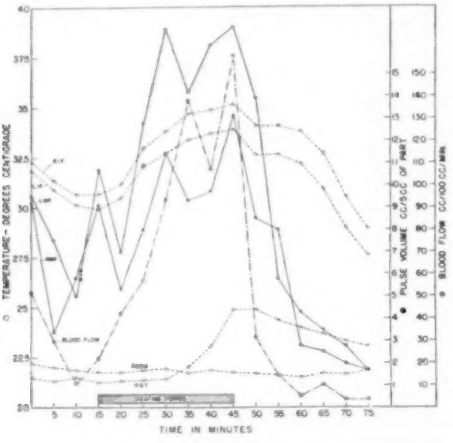

Fig. 3. — Microwave director C — 97.5 watts — right forearm 2 in. distance. Temperatures are indicated by dotted line; pulse volumes by solid line. Illustrates parallelism of finger temperatures, pulse volume, and blood flow. Toe temperature is relatively low, and rise occurs later. Rapid fall of digital temperature, pulse volume, and blood flow after end of heating period.

in the forearm was severer. In less than five hours the right forearm became swollen and there was a reddened area 4 by 8 cm. with two blebs, (2 by 0.5 cm. and 1 by 0.5 cm.). There were numerous small blisters. Furthermore,

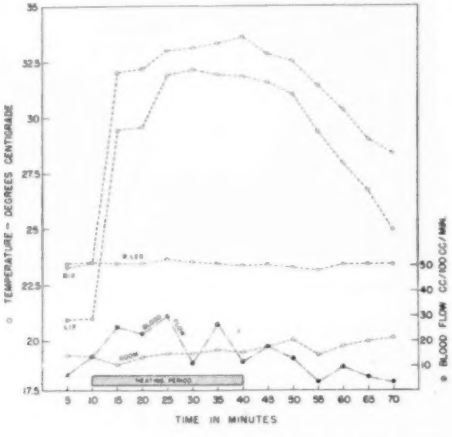

Fig. 4. — Microwave director C — 87.5 watts — right forearm 2 in. distance. Illustrates a rapid response in finger temperature but small increase in blood flow when initial temperatures are low.

there was induration of the subcutaneous tissues of the reddened area. In eight hours the area was hot and sore but no discomfort was present when the underlying muscles were used. In 24 hours the redness had faded but

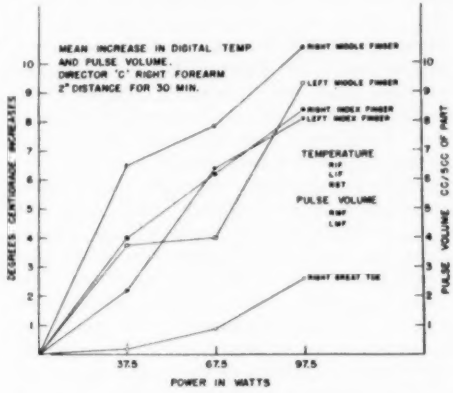

Fig. 6. — Digital temperature and pulse volume tend to be parallel and vary directly with power output.

the blebs and the subcutaneous induration were still present. There was no discomfort at this time. In 72 hours some of the blisters and blebs had ruptured during the night. In five months the area was healed, although some induration still persisted. At the time of writing the scar tissue remains tender.

In none of the burns was the sensation of pain intense. When the subject did complain, it was of a throbbing, aching, or burning and usually occurred during the first five minutes of exposure.

Comment

In any study dealing with the response to heating, the regulation of the circulation comes into consideration. There are proponents for the mechanism of warm blood traveling to the hypothalmus and there are others showing evidence for a reflex neural mechanism.[6] One fact is outstanding — that heat to the body in sufficient quantity will (in nearly all normal persons) produce vasodilatation.[7] The response as to the amount of vasodilatation depends on many variables, such as environmental temperature, food, drugs, smoking, and vasomotor tone.[8] Montgomery[8c] expressed the opinion that

6. (*a*) Ferris, B. G.; Forster, R. E.; Pillion, E. L., and Christensen, W. R.: Control of Peripheral Blood Flow Responses in Human Hand When Extremities are Warm, Am. J. Physiol. **150**:304, 1947. (*b*) Hammouda, M.: The Central and Reflex Mechanism of Panting, J. Physiol. **77**:319, 1933. (*c*) Gibbon, Jr., J. H., and Landis, E. M.: Vasodilatation in the Lower Extremities in Response to Immersing the Forearm in Warm Water, J. Clin. Investigation **11**:1019, 1932. (*d*) Barbour, H. G., and Prince, A. L.: The Control of the Respiratory Exchange by Heating and Cooling the Temperature Center, J. Pharmacol. & Exper. Therap. **6**:1, 1914-1915. (*e*) Pickering, G. W.: The Vasomotor Regulation of Heat Loss From the Human Skin in Relation to External Environment, Heart **16**:115, 1911. (*f*) Grant, R. T., and Holling, H. E.: Further Observations on the Vasomotor Response of the Human Temperature to Body Warming, Clin. Sc. **3**:273, 1938. (*g*) Duthie, J. J. R., and Mackay, M. L.: Vasomotor Reflexes in the Control of Body Temperature in Man, Brain **63**:295, 1940. (*h*) Goetz, R. H., and Ames, F.: Reflex Vasodilatation by Body Heating and Diagnosis of Peripheral Vascular Disorders, Arch. Int. Med. **84**:396, 1949. (*i*) Lewis, T.: Vascular Disorders of the Limbs, New York, The MacMillan Company, p. 96, 1936.

7. Fatherree, T. J., and Allen, E. V.: Sympathetic Vasodilator Fibers in Upper and Lower Extremities; Observations Concerning Mechanism of Indirect Vasodilation Induced by Heating, Arch. Int. Med. **62**:1015, 1938.

8. (*a*) Abramson, D. I., and Fierst, S. M.: Peripheral Vascular Response in Man During Digestion, Am. J. Physiol. **133**:686, 1941. (*b*) Gubner, R.; DiPalma, J., and Moore, Elizabeth: Specific Dynamic Action as a Means of Augmenting Peripheral Blood Flow, Am. J. M. Sc. **213**:46, 1947. (*c*) Montgomery, H.: The Effect of Drugs on the Circulation of Normal Hands and Feet, ibid. **203**:882, 1942. (*d*) Macht, M. B.: The Effects of Various Amino Acids on Peripheral Blood Flow and Skin Temperature, J. Clin. Investigation **29**:454, 1948. (*e*) Bader, M. E., and Macht, M. B.: Indirect Peripheral Vasodilatation Produced by the Warming of Various Body Areas, Applied Physiol. **1**:215, 1947.

it is not valid to consider the amount of increased temperature of blood flow, but rather the actual temperature in centigrade degrees and blood flow in cubic centimeters per 100 cc. of tissue per minute should be stated.

If the criterion for full vasodilatation is taken as digital temperature of 31 C. or over,[9] then microwave did not produce full vasodilation in any of our subjects. However, it did produce vasodilatation in the digits of the hands but not of the feet. This differential response of hands and feet has been noted by Horton, Roth, and Adson.[10] They observed that, regardless of the vasodilating agent, a rise of surface temperature in the fingers invariably preceded that of the toe. Also, there is a distinct vasomotor gradient with reference to the face, hands, and feet in normals.[11]

According to Grant and Holling,[6f] there are two means of defense against a rise of body temperature. First, relatively gentle heating leads to dilatation of arteriovenous anastomoses in the extremities caused by inhibition of vasoconstrictor tone, and, second, more intense heat leads to general dilatation of cutaneous vessels and is associated with sweating. These are caused by stimulation of the sympathetic nerves and serve to increase dissipation of heat from the skin. Both types of response were seen in our subjects.

That digital temperature can be a reliable measurement of digital blood flow has been established by Montgomery.[8c] However, there is a time lag, and temperature measurements do not show up rapid fluctuations in the blood flow. Burton[4a] stated that pulse volume under certain conditions is a good index of digital blood flow. For many of our procedures we used digital temperature, pulse volume, and blood flow. Because of their close correlation, we did our final experiments using only digital temperatures. Montgomery[8c] has published a graphic curve whereby, if the digital temperature, blood flow per 100 cc. of digital tissue per minute can be read directly.

According to a report of Wakim and others,[11] the temperature of tissues heated locally by microwave reached their maximum in 15 to 20 minutes' exposure, after which a fall of tissue temperature from this peak, due to an increase in blood flow, occurred. This fits in well with the findings that digital temperature and digital blood flow were at their peak at the end of the heating period. In a study by Wakim, Herrick, Martin, and Krusen,[11] it was found by venous plethysmography that the blood flow was greatly increased in the exposed extremity, but that the untreated arm showed no increase. However, by carefully reading the procedure one finds that these authors measured the blood flow in the untreated arm about 6.8 minutes after the end of the heating period. Our findings have indicated that within five to 10 minutes after end of the heating period there is in the majority of cases a vasoconstriction of the digits of both treated and untreated arms; hence any increase in blood flow would have been overlooked. Furthermore, they were measuring the blood flow in the extremity and not in the digits.

Horvath, Miller, and Hutt,[4a] in a study of the heating of the thigh with microwave radiation, found no evidence of reflex vasodilatation as determined by multiple toe and finger temperature measurements. Nevertheless, we have found that heating of the forearm produced vasodilatation in the digits of the upper extremities at the same time and of about the same degree but vasodilatation was not produced in the toes. We also heated the thigh and

9. Montgomery, H.; Naidle, M., and Freeman, N. E.: Vasodilatation Test, Am. Heart J. 21:788, 1941.
10. Horton, B. T.; Roth, Grace, and Adson, A. W.: Observations on Some Differences in the Vasomotor Reaction of the Hands and Feet, Proc. Staff Meet., Mayo Clin. 11:433, 1936.
11. Roth, Grace; Horton, B. T., and Sheard, C.: Relative Roles of Extremities in Dissipation of Heat From Human Body Under Various Environmental Temperatures and Relative Humidities, Am. J. Physiol. 128:782, 1940. Bader, M. E.; Macht, M. B., and Pillion, E. L.: Peripheral Vascular Effects Produced by Localized Warming of Various Skin Areas, Federation Proc. 7:4, 1948. Martinez, M. B., and Visscher, C.: Some Observations on General Skin Temperature and Respiration to Local Heating of Human People in Cold Environment, Am. J. Physiol. 144:724, 1945. Bader and Macht.[8c] Horton, Roth and Adson.[10]

got the same results as when treating the forearm. Perhaps in the cases of these authors vasodilatation had already been produced by the warm environment or by food.

Rae and co-workers[11] have found that in dogs the C director produced highest temperatures. Our experience with the A director leads us to believe that its output is either much less than that of the B and C directors with similar skin distances and power output, or else it is more evenly distributed. In fact, with use of the A director with 112.5 watts of power no erythema was produced in two subjects. The C director, however, focuses the radiation to a small area. Using this fact, Oldendorf[12] was able to produce focal lesions in the cortex of rabbits.

The subject with scleroderma who was 72 years old was treated with director A using 37.5 watts of power. Her disease had progressed almost to her elbows. There was no increase of digital blood flow in the right middle finger, but the opposite finger showed an increase in the size of the pulse volume. Digital temperature was increased bilaterally 1 to 2 degrees C. Toe temperature fell gradually throughout the procedure.

The dangers of microwave should be emphasized, as burns can occur with little discomfort and with less warning than when standard short wave generators are used. Also to be considered is the excessive heating of metals implanted in the tissues.[13] Bony prominences, too, are areas of excessive heating. In studying the effect of microwave on bones and tissues of rats Wise, Castleman, and Watkins[14] found extensive bone absorption and resulting flail extremity as a sequalae to a microwave burn. The damaging effect of ischemia as shown by Worden and his colleagues[15] is important, especially if the treatment is carried out for the usual length of time (15 to 20 minutes). Osborne and Frederick[16] found no evidence of damage to the eyes of dogs after exposure to microwave, but Salisbury, Clark, and Hines,[17] using microwaves with a wavelength of 12 cm. for 10 minutes with a field intensity of about 3 watts per square cm., produced cataracts in the eyes of rabbits. They stated the opinion that the loss factor at wavelengths of about 10 cm. was such that the highest temperature occurred near 1 cm. beneath the skin surface in tissues not cooled by a good blood flow. Thus burns may occur without due warning by the usual sensation of pain. They further specified that since there is no standard of safety, microwave radiation should be treated with the same respect as any other energetic radiation, such as x-rays, alpha rays, and neutrons.

The three burns that were encountered in our subjects, together with the warnings of others, show that the haphazard use of microwave radiation is dangerous and that considerable judgment must be used in its application. Important factors to be considered are the presence of bony prominences, the local blood supply, implanted metals, the depth of the tissues over the bone, the type of director, and the power output to be used. As has been mentioned previously, the C director has been utilized to produce focal cortical lesions in rabbits.[12]

12. Oldendorf, W. H.: Focal Neurological Lesions Produced by Microwave Irradiation, Proc. Soc. for Ex. Biology and Med. **72**:132, 1949.
13. Feucht, B. L.; Richardson, A. W., and Hines, H. M.: The Effects of Implanted Metals on Tissue Hyperthermia Produced by Microwaves, Arch. Phys. Med. **30**:164, 1949. Boyle, A. C.; Coole, H. F., and Buchanan, T. J.: The Effect of Microwave — A Preliminary Investigation, Brit. J. Phys. Med. **13**:2, 1950.
14. Wise, C. S.; Castelman, B., and Watkins, A. L.: Effect of Diathermy (Shortwave and Microwave) on Bone Growth in the Albino Rat, J. Bone & Joint Surg. **31-A**:487, 1949.
15. Worden, R. E.; Herrick, J. F.; Wakim, K. G., and Krusen, F. H.: The Heating Effects of Microwave With and Without Ischemia, Arch. Phys. Med. **29**:751, 1948.
16. Osborne, S. L., and Frederick, J. N.: The Heating of Human and Animal Tissues by Means of High Frequency Current of 12 cms. Wavelengths (The Microtherm), Quart. Bull., Northwestern Univ. M. School **23**:222, 1949.
17. Salisbury, W. W.; Clark, J. W., and Hines, H. M.: Exposure to Microwave, Electronics **22**:66, 1949.

In several experiments, the temperature of the surface of the heated forearm was recorded. These temperatures were taken at various distances from the center of the heated area. Maximum temperature recorded was 44.1 C. with only the sensation of warmth. In another procedure, the maximum surface temperature recorded with use of four separate thermocouples was 40.6 C. but heating had to be discontinued because of severe aching in the muscle. It is felt that although the thermocouple readings were subject to error, being in the microwave field, they did indicate that surface temperatures are not extremely high.

Summary and Conclusions

Sixty experiments were performed on 16 subjects to observe the effects of microwave irradiation applied to the forearm on digital blood flow, pulse volume, and temperature. Various types of directors and different power output were utilized. The heating period of 30 minutes and the 5 cm. distance between the director and skin were kept constant.

On the basis of the experimental evidence the following conclusions can be supported:

1. Microwave irradiation of the forearm does not increase oral temperature or pulse rate.
2. Vasodilatation is rapidly induced in both hands at the same time and to about the same degree.
3. Complete vasodilatation was not produced in any of our subjects by treatment with microwave.
4. The changes in digital pulse volume, temperature and blood flow of the upper extremities in response to heating the forearm with microwave radiation were parallel and varied directly with the power output that was applied.
5. Burns from microwave energy can be sustained with only minor discomfort during the time of exposure.

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.·. EDITORIALS .·.

THE VALUE OF PHYSICAL MEDICINE TO THE INTERNIST

Those whose dominant interest is physical medicine and rehabilitation often are asked by internists to explain what physical medicine has to offer, that is otherwise unobtainable, as an adjunct to diagnosis and management of patients that fall within the subdivisions of internal medicine, as broadly defined. There are other special fields of medical activity in which the value of physical medicine has long been recognized, notably orthopedics, traumatic, neuro and thoracic surgery and neuropsychiatry. The most inclusive medical specialty — internal medicine, except in the case of several subspecialties, has been conspicuously indifferent to the therapeutic possibilities of physical medicine. What may the internist expect from the physiatrist?

The first question is one of definition. For this discussion how broadly inclusive is internal medicine to be regarded? The internist frequently finds himself concerned with patients whose diseases do not properly fall within his bailiwick. Such patients seen only in an advisory capacity cannot properly be regarded as problems in internal medicine. In addition, although often seen initially by an internist, the disabilities resulting from trauma, surgical and orthopedic conditions, all organic neurological disorders, neuropsychiatric and psychiatric disturbances do not fall within the category of internal medicine. The adoption of such restrictions furnishes a basis for the selection of the type of patients that properly are the responsibility of the internist.

There are two important groups of patients whose relationship to internal medicine is often not clear: (1) those that have sustained cerebral vascular injuries and (2) cases of poliomyelitis, suffering from some degree of residual paralysis. In the first group the underlying cause, vascular degeneration, embraces the most widespread and important field in internal medicine. On the other hand, the neuro-motor sequelae which result from the vascular accident are definitely within the realm of the neurologist. Whether these patients are regarded as the responsibility of internists or neurologists is largely academic. If they are to be managed properly and restored as rapidly as possible to useful living they must be placed under the care and supervision of the physiatrist. Most cerebral vascular cases are seen originally by general practitioners or internists. Therefore, in the rehabilitation of these individuals the internist may obtain invaluable help from his colleagues in physical medicine.

At the onset of their disease, poliomyelitis patients usually come under the observation of the general practitioner, the internist or the pediatrist. As the age incidence of poliomyelitis has increased in our Eastern cities, internists have been seeing a greater number of adults suffering from acute poliomyelitis. During the acute infectious stage of the disease, when life may be threatened, the problem of management rests in the hands of the attending doctor. When respiratory failure or any degree of paralysis develops the alert internist calls for the cooperation and advice of the physiatrist and his technical associates. Any degree of muscle weakness or paralysis in a polio-

myelitic entitles such a patient to the expert care of the physiatrist. In this group of borderland cases, again, the internist may derive essential aid from physical medicine.

The most extensive class of patients that come within the purview of the internists, for whom he must turn to physical medicine for help, are the chronic arthritides and those who suffer from allied rheumatoid disorders. The value of physical therapy to the arthritics is beyond question. The late Dr. Bernard Comroe pointed out that physical medicine is an indispensable adjunct in the management of most arthritics, particularly those who have reached the sub-acute and chronic stages of the disease.

It should be emphasized that, contrary to popular opinion, the important place of physical medicine in the management of the arthritic has not been usurped by recent advances in hormonal therapy. The advent of cortisone and ACTH has not lessened the necessity for physical therapy. Present evidence indicates that none of these new and much discussed drugs have thus far cured chronic arthritis. They have, however, been of inestimable advantage in controlling pain and muscle spasm thus enabling physical therapists to carry out effectively measures necessary to restore maximum range of joint motion, to overcome contractures and correct deformities. Until more is known of the action of the adrenal cortical hormone and further advances have taken place in this field of therapy, the internist will continue to depend upon his colleague in physical medicine, to give patients suffering from chronic arthritis and allied disorders maximum therapeutic advantages.

Disorders of the cardiovascular system make up the largest percentage of patients who seek the advice of internists. In view of the medical, social and economic importance of this group of diseases it is timely to inquire what, if anything, physical medicine offers the internist in the management of this expanding field. The importance of physical and mental rest in those suffering from myocardial insufficiency has long been accepted. However, unnecessarily prolonged rest is capable of bringing about harm as well as good. Recognition of this has led to the more recent policy of avoiding excessively prolonged bed rest even in those suffering from coronary occlusion and acute rheumatic disease.

Graduated exercise in the management of myocardial insufficiency is not new and antedates the present wave of enthusiasm for early ambulation by many decades. The internist of today overlooks the value of resistance exercises performed under medical direction by trained attendants which have proven of unquestioned help in the management of properly selected cardiac patients. Nauheim baths and other types of hydrotherapy may be cited as additional examples of recognized procedures in physical medicine which may be used with advantage in some types of myocardial degeneration. The clinical value of selected physical procedures in suitable cases has been amply demonstrated by careful observations over the years. In this age dedicated to electromyography, ballistocardiograms, cardiac catheterization, surgery, and modern scientific drug therapy it is unlikely that internists will seek out their physiatric colleagues to institute the more time consuming forms of physical therapy in their cardiac cases.

Many attempts have been made to discover some form of physical therapy useful in the management of angina pectoris and coronary disease. Since Nagelschmidt's observations in 1911 on short wave diathermy in the treatment of coronary artery disease numerous reports have appeared on this subject. The results obtained have not been encouraging. As Bierman pointed out it is difficult to attribute any special value to short wave currents in the treatment of angina pectoris, since the disease is subject to sponta-

neous remissions, and rest with other forms of treatment are concurrently used with the diathermy. The results claimed by some are but another example of the danger of evaluating the effect of physical therapy from uncontrolled clinical observations.

The search for some procedure in physical therapy that would be of help to the internist in controlling so-called primary or essential hypertension has been unsuccessful thus far. It is dangerous to appraise the value of any form of physical treatment from its effect on a symptom such as hypertension, the etiology of which is unknown, which is subject to wide physiological variations and is profoundly influenced by physical rest and psychological factors.

The internist has looked with some optimism upon the role of physical medicine in the management of peripheral vascular disease. It is encouraging that both from a diagnostic and therapeutic standpoint physical medicine is a valuable ally to the internist in the care of these patients.

The objective of the internist in the management of peripheral arteriosclerotic vascular disease is to bring about, by every possible means, effective increase of the circulation in the affected extremity. In accomplishing this, certain procedures in physical medicine have been found useful.

Thanks to physiologists, physiatrists have learned lessons which have radically altered the management of peripheral vascular occlusion. Not many years ago the uncritical use of heat and elevation of the part when arterial occlusion had taken place was the rule. The work of Landis and Gibbon, Starr and others made it clear that the direct application of heat to an area in which arterial occlusion had taken place is productive of harm. The application of heat increases the local metabolic activity of a part, which in turn brings about a demand for additional oxygen. This can only be met by increased arterial circulation. Any degree of arterial obstruction induces, therefore, a relative ischemia with its resulting tissue changes leading to gangrene. On the other hand, it has been demonstrated that when heat is applied to uninvolved parts of the body in sufficient degree and duration, there occurs a secondary reflex vasodilatation in the affected extremity which is beneficial and free of the disastrous results of the direct application of heat. Even now these facts are not always as carefully observed as they should be in the management of peripheral vascular disease.

Another important group of patients which claims the attention of the internist are those suffering from acute infections. When the etiology of many infectious diseases was unknown, and a specific therapeutic approach was lacking, internists depended in no small measure upon simple forms of hydrotherapy in managing the toxemia and hyperpyrexia that accompanied infectious diseases of long duration, such as typhoid fever. Various forms of hydrotherapy were used in many ways. Hot baths were employed for convulsive and agitated states. They were helpful in relaxing the muscle spasm incident to the passage of calculi; as an aid in the reduction of strangulated or incarcerated hernia. Thus, unwittingly, perhaps, internists have depended upon physical medicine in the management of patients. Although modern therapeutic advances have lessened the necessity for such procedures there are still many opportunities in the practice of internal medicine when physical therapy could be employed to advantage.

The advent of fever therapy opened up a great opportunity for the physiatrist to help the internist in the management of neurosyphilis, in the severe forms of infectious arthritis, gonococcal infection and other serious bacterial invasions. Today the necessity for fever therapy grows steadily less. First chemotherapy, later the antibiotics have furnished the internist far safer

and more effective methods of dealing with infections than any plan devised by physical medicine. It is true that in intractable local infections of unknown etiology, in certain types of atrophic arthritis, in some instances of neurosyphilis and in patients who harbor sulfa or penicillin-resistant strains of organisms fever therapy has its usefulness. On the whole, this aspect of physical medicine is of diminishing importance to internal medicine.

Such technical procedures as the introduction of certain drugs through the tissues by means of galvanic current (ion transfer) have from time to time been recommended by physiatrists in the management of various conditions, as for example — arthritis. The procedure has elicited little enthusiasm from internists. Even among physiatrists the efficacy of the technique is subject to discussion. The local good which it may accomplish is certainly no more than may be achieved by the conventional methods af administering the drugs in question.

In the fields of gastroenterology, allergy and the medical aspects of pulmonary disease there appears to be little that physical therapy offers that cannot be more satisfactorily and promptly accomplished by other methods available to the internist.

If one excludes the acknowledged value of physical medicine as an adjunct in the management of arthritis and allied disorders, peripheral vascular disease and the neuromuscular sequellae of vascular, infectious and degenerative disturbances of the nervous system, there remain but few conditions within the domain of internal medicine proper in which physical medicine is of much significance. If an analysis of the relationship between these two important fields of medicine stopped at this point one would be forced to the discouraging assumption that they had little in common. Fortunately, such a conclusion is unwarranted and unjustifiable now that the older conventional concept of physical therapy is replaced by the modern, broad understanding of the objectives and ultimate aim of physical medicine as presently defined.

Physical medicine, happily, has ceased to be merely a means of offering added methods of symptomatic relief. Physical medicine has taken its place among accredited specialties as the one field of medical endeavor dedicated to the retraining and rehabilitation of the sick and disabled. Regarded in that light physical medicine offers to internal medicine unlimited facilities for the restoration of the patient as a whole. When internists come to the realization that their obligation to patients involves not just saving life but the restoration of maximum physical, mental, social and vocational possibilities, they will become eager to avail themselves of the help of physiatrists trained in the special techniques of dynamic medicine.

The rehabilitation of medical patients should not be restricted to the care of the convalescent and chronically ill. Internists should insist upon the introduction of reconditioning methods into the medical wards. Proper bed posture, breathing exercises, various modifications of bed exercise, associated with skillful local or general massage suggest some of the possibilities constantly available to the internist aware of the potentialities of the physical medicine of today.

As progress in medical science succeeds in converting us into a nation of older people, internal medicine will be forced to assume increasing responsibility for the ever expanding number suffering from chronic degenerative diseases. Since physical medicine, as presently understood, offers the most rational approach to the management of this group, it is not unreasonable to predict that in the near future the internist will develop greater appreciation of and dependence upon physical medicine.

SPECIAL REPORT

The Baruch Committee on Physical Medicine and Rehabilitation

Dr. Frank H. Krusen of Rochester, Minnesota, Chairman of the Baruch Committee on Physical Medicine and Rehabilitation has announced that the committee has achieved its goals and is discontinuing its activities. At the same time Mr. Bernard M. Baruch, New York City, the sponsor of the committee, which has been active since November, 1943, announced that he was watching the institutions to which he had made grants, on recommendation of the committee, and that it was his object to make further grants "to those who undertake the work with enthusiasm and beneficial results."

The committee had been formed by Mr. Baruch to develop and advance the special field of medicine devoted to the diagnosis and treatment of disease by physical agents and to the rehabilitation of disabled persons. Mr. Baruch has provided well over $2,000,000 of his personal fortune to support this branch of healing in honor of his father, the late Dr. Simon Baruch, who was the leading medical pioneer in this field.

As one of its final acts, the committee has made a grant to promote the organization of an International Congress of Physical Medicine to be held in London, England, on July 14 to 19, 1952. This congress will promote the further development of physical medicine and rehabilitation on a global scale.

The committee announced that in achieving its goals its activities had been largely instrumental in bringing about:

(1) A marked increase in the teaching of physical medicine and rehabilitation in the medical schools of America.

(2) An extensive increase in the number of residencies in physical medicine and rehabilitation

(3) The rehabilitation of many thousands of wounded soldiers and sailors as well as still greater numbers of person injured in cilivian life.

(4) Complete recognition of the new medical specialty of physical medicine and rehabilitation.

(5) The establishment of a new Section on Physical Medicine and Rehabilitation in the American Medical Association.

(6) The organization of an American Board of Physical Medicine and Rehabilitation to certify qualified specialists in this field.

(7) Stimulation of the establishment of community rehabilitation centers throughout the country.

(8) Clarification of the standards for determination of the physical fitness of the workers of the nation.

(9) Improvements in the teaching of medical physics.

The program of the committee has included:

(1) Publication of five major reports which informed the medical profession and the public at large concerning the modern developments in physical medicine and rehabilitation.

(2) Provision of fellowships for forty-eight physicians to train them to specialize in this branch of medicine.

(3) Establishment of three major centers of physical medicine and rehabilitation at the medical schools of Columbia University, New York University and the Medical College of Virginia.

(4) Establishment of special projects in teaching and research at various medical schools scattered throughout the United States.

(5) Publication of over 250 scientific articles on physical medicine and rehabilitation.

The Baruch Committee reported that when it began its activities only 42 per cent of the nation's medical schools were offering instruction in physical medicine and rehabilitation while today, largely owing to its efforts, over 67 per cent of the medical schools are providing such instruction and another 20 per cent are planning to do so.

It was added that when the committee started its work only three medical centers offered residencies in physical medicine and rehabilitation while today over eighty residencies are available at forty different medical centers scattered throughout the United States.

Furthermore, when the Baruch Committee began its work the special field of physical medicine and rehabilitation was not generally recognized by the medical profession but today, chiefly through the efforts of the committee and other medical groups, the American Medical Association has established a permanent Section on Physical Medicine and Rehabilitation. Also, on recommedation of the committee, the Advisory Board for Medical Specialties has established a specialty Board on Physical Medicine and Rehabilitation to certify physicians in this field of medical practice. Thus physical medicine and rehabilitation became the sixteenth medical specialty to become recognized. This occasioned a remark by Mr. Baruch to the committee that: "You have made physical medicine and rehabilitation an accepted branch of medicine."

Dr. Krusen said that this was an extremely significant development and in thanking his associates he added: "Your work has brought into being a new medical specialty which has already demonstrated its ability to bring relief to many thousands of sick and disabled persons and to restore other thousands of handicapped people to useful citizenship. It has laid the groundwork for the restoration, in the future, of untold millions of crippled children and adults to the fullest possible physical, social and economic usefulness to themselves and to the nation. Mr. Baruch's generosity and your labors have been humanitarian contributions of tremendous magnitude toward the welfare of our democracy."

Dr. Krusen, who has been Executive Director of the committee since its inception and who suc-

ceeded the late Dr. Ray Lyman Wilbur (former Secretary of the Interior) as Chairman of the Committee following Dr. Wilbur's death in June, 1949, paid tribute to the inspiring example set by Dr. Simon Baruch, the kindly generosity and wise counsel of Mr. Bernard M. Baruch, and the remarkable leadership of Dr. Ray Lyman Wilbur in the organization of the work of the committee.

Dr. Krusen also extended his thanks to the other medical scientists who served on the committee and who, with the aid of many subcommittees, have completed the work so expeditiously. The members of the Baruch Committee include: Dr. John F. Fulton of Yale University; Dr. Charles G. Heyd of Columbia Universtiy; Dr. Andrew C. Ivy of the University of Illinois; Dr. Chauncey C. Leake of the University of Texas; Dr. Frank R. Ober of Harvard University; Dr. Winfred Overholser of St. Elizabeth's Hospital, Washington, D. C.; Dr. Howard A. Rusk of New York University; Dr. Alfred R. Shands, Jr. of the Alfred I. duPont Hospital for Crippled Children, Wilmington, Delaware; Dr. Francis O. Schmitt of Massachusetts Institute of Technology; Dr. William S. Tillett of New York University and Dr. Arthur L. Watkins of Harvard University.

In commenting to the Chairman on the discontinuance of the work of the Baruch Committee and on the achievement of its goals, Mr. Baruch wrote: "Evidently we have come to the same conclusion on the desirability of the termination of the Baruch Committee on Physical Medicine and Rehabilitation.

"I am deeply grateful to you and your associates for the intelligent and effective way in which you have worked on every occasion. I have demonstrated my confidence in your committee's work by accepting all your recommendations.

"I feel pleased that the work of the Committee has finally culminated in the goal towards which my father strove. You have made physical medicine and rehabilitation an accepted branch of medicine. I have seen with my own eyes the evidences of the results in the Veterans and other hospitals. I saw it in your own well run Section on Physical Medicine and Rehabilitation at the Mayo Clinic.

"The grants which you have recommended I hope will result in a source of permanent alleviation to the injured and handicapped.

"I am watching the several institutions to which your committee recommended various grants and hope you will give me your judgment about them from time to time for it is my object to make further grants to those who undertake the work with enthusiasm and beneficial results."

During the period of its activities the Baruch Committee published five major reports which were widely distributed and which served to provide much information to medical scientists throughout the world concerning the modern advances in physical medicine and rehabilitation.

The committee also has provided fellowships in physical medicine and rehabilitation for forty-eight young physicians. It has established three major centers of physical medicine and rehabilitation at Columbia University, New York University and the Medical College of Virginia. The committee also has provided grants for projects in teaching and research at medical schools throughout the United States including George Washington University, Harvard University, University of Illinois, University of Iowa, Marquette University, Massachusetts Institute of Technology, University of Minnesota, University of Southern California and Washington University of St. Louis.

The committee lists over 250 scientific publications dealing with teaching, research and practice in physical medicine and rehabilitation which have been prepared by the projects supported by the committee at these institutions.

Dr. Howard A. Rusk of New York University as Chairman of the Subcommittee on Community Rehabilitation Centers reported that his group has prepared a special report which was widely distributed throughout the world and which was translated into French. This report has stimulated the organization of rehabilitation centers in many communities from coast to coast as well as in foreign countries. In commenting on this project, the president of a large hospital in Pennsylvania said that the movement has progressed far enough so that if the representatives of the Baruch Committee did nothing further, "the battle has been won and physical rehabilitation plans will spread over the entire country."

Dr. Krusen said he believed that the Subcommittee on War and Postwar Physical Rehabilitation which met in Washington, D. C., every 60 days during World War II was largely instrumental in developing the fine military programs for the rehabilitation of wounded soldiers and sailors and laid the groundwork for the excellent program of medical rehabilitation of veterans which extends throughout the Veterans Administration Hospitals.

Dr. Robert C. Darling of Columbia University reported that his Subcommittee on Physical Fitness has published a detailed study of this important subject which has been widely distributed.

Dr. Francis O. Schmitt of Massachusetts Institute of Technology, Chairman of the Subcommittee on Teaching of Physics said that his committee has aided considerably in laying plans for better courses in premedical physics so that physicians will have a better understanding of the treatment of disease by physical agents. Special grants were made by the committee to the American Association of Physics Teachers in promotion of this project.

BOOK REVIEWS

FEVER THERAPY. By *H. Worley Kendell*, M.D., F.A.C.P. Professor of Physical Medicine and Rehabilitation, University of Illinois Research and Educational Hospitals, Chicago. Publication Number 80, American Lecture Series. A Monograph in Physical Medicine. Edited by *W. A. Selle*, Ph.D., Professor of Biophysics, University of California Medical School, Los Angeles; formerly Professor of Physiology and Medical Physics, Director of Postgraduate Courses in Physical Medicine, University of Texas, Medical Branch, Galveston, Texas. Lexide. Price, $2.25. Pp. 107, with 15 illustrations. Charles C Thomas, 301-327 East Lawrence Ave., Springfield, Illinois, 1951.

Fever Therapy is another monograph in American Lectures in physical medicine. This small but complete work by H. Worley Kendell is an unusually fine contribution and will be extremely valuable to those physicians who are interested in fever therapy.

Kendell has used rare judgment in the selection and presentation of the subject. The text is well illustrated and written in clear, concise language. It is always difficult to write a small volume but Kendell has done this in a masterly manner. The following chapters are presented: introduction; methods of producing physically induced fever; technique; principles of fever therapy; complications; therapeutic indications; summary; and an excellent list of references. Kendell has had a rich experience with fever therapy and fever therapy combined with chemotherapy. Both Kendell and the publisher are to be congratulated for producing such an excellent and useful monograph—it is highly recommended.

EXPERIMENTAL PHYSIOLOGY WITH ANATOMICAL AND MECHANICAL ILLUSTRATIONS AND AN APPENDIX OF TECHNICAL DATA. By *Maurice B. Visscher*, Ph.D., M.D., Professor and Head of the Department; *Ernest B. Brown*, Ph.D., Assistant Professor; and *Nathan Lifson*, M.D., Ph.D., Professor, Department of Physiology, University of Minnesota, Minneapolis. Paper. Price, $2.75. Pp. 126 with 46 illustrations. Burgess Publishing Company, 426 South Sixth Street, Minneapolis 15, 1951.

This laboratory manual for physiology is a revision of an earlier one and has been largely rewritten. The authors state they present working descriptions for the procedures found practicable in their own physiological laboratories at the University of Minnesota. In selecting the sample experiments the authors have been guided by practical considerations of simplicity and availability of equipment as well as the inherent importance of the observations to be made. The contents are as follows: general properties of protoplasm; the mechanisms of muscular activity; the circulatory system; the mechanisms of respiration; the mechanisms of nervous activity; physiology of the sensations; gastro-intestinal function; nutrition, metabolism and internal secretion; secretion of urine; and finally a very useful appendix. The directions for each experiment are explicit and well outlined. The use of such terms as "tetanizing current" in place of the older term "faradic" and "direct current" for "galvanic" is both pleasing and commendable. The authors might change the term "indifferent electrode" to "dispersive electrode" which more accurately describes its purpose. Physiologists should find this excellent manual an addition to their library for reference or even adoption. Schools of physical therapy might find this useful although somewhat advanced. There are 46 line drawings that add much to this desirable text. It is well recommended.

PARASITIC INFECTIONS IN MAN. Edited by *Harry Most*. Symposium Held at the New York Academy of Medicine, March 15 and 16, 1949. Cloth. Price, $4.50. Pp. 229, with illustrations. Columbia University Press, 2960 Broadway, New York 27, 1951.

In 1947 the Fellowship of the New York Academy of Medicine approved the organization of the section on Microbiology. This was the first section of the Academy devoted to basic medical sciences. Several symposia are organized yearly and the participants present extensive reviews in their particular fields of endeavor, bringing correlated and authoritative scientific data and concepts to the attention of the microbiologists and allied laboratory and clinical investigators. Important service is rendered by the Columbia University Press which has published this series under the auspices of the New York Academy of Medicine.

In the introduction, Russell of the Rockefeller Foundation points out that the Protozoan and Helminthic Parasites of man bring ill health and early death to millions of humans yearly with unrelenting persistence. Stoll has surveyed the world's burden of parasitic helminths and added together some impressive data. Stoll's tentative but carefully formed generalization as to the total number of helminthic infections was 2.2 billions in an estimated world population of 2.17 billions. Some of the approximate totals were: schistosomiasis, 114 millions; filariasis, 189 millions; hookworm, 457 millions; and Ascaris, 644 million cases. He also estimated that the United States has 20 million cases of trichinosis — three times

more than reported for the rest of the world. Russell states that amoebiasis appears to be increasing in incidence. He also points out that these parasitic diseases bring about not only bodily disaster but a lowered output of labor, lost initiative and reduced food supplies. Therefore it is a matter of tremendous and increasing importance to reduce the incidence of these diseases.

While basic facts of etiology, control and prevention of these parasitic diseases have been known for many years, man has not been clever enough to put this knowledge to sufficient practical use. Russell pleads for the control of these diseases through the operation of known principles of public health.

The fourteen chapters, each written by a specialist in his field are as follows: the significance of new findings in the life cycle of malarial parasites; immunological mechanisms in parasitic infections; immunological diagnosis of parasitic diseases; diagnosis of intestinal helminths and protozoa; studies on growth and metabolism of endamoeba histolytica; the physiology of blood flagellates; biochemistry and metabolism of malarial parasites; the cultivation of malarial parasites; metabolism of helminths; pharmacologia evaluation and clinical application of amebacides with special reference to the thoarsenites; the status of antimalarial drugs; theory of filariasis and the more common intestinal helminths; and the treatment of schistosomiasis. The volume is well written and documented with excellent references at the end of each chapter. This is an important work and well worthy of study. It is essential that the entire medical profession becomes acquainted with the problem so that they can lend their assistance in meeting this public health problem so vital to mankind.

CLINICAL THERAPEUTIC RADIOLOGY. Edited by *U. V. Portmann*, M.D., Head of Department of Therapeutic Radiology, Cleveland Clinic Foundation. Cloth. Price, $15.00. Pp. 748, with illustrations. Thos. Nelson & Sons, 385 Madison Ave., New York 17; Parkside Works, Dalkeith Road, Edinburgh 9; 3 Henrietta St., London, W.C.2. 1950.

Within the last 20 years radiology has grown to such an extent that no single individual can be authority on all its phases. That even applies to many of its subdivisions, such as for example, therapeutic radiology. For that reason more and more books are now written by a group of experts rather than by one single author. Clinical Therapeutic Radiology is also such a collaborative effort. U. V. Portmann, one of the leaders in the field of therapeutic radiology, has been eminently successful in selecting as collaborators other leaders in their respective fields. Names like Arneson, Blady, Buschke, Cahill, Cipollaro, Ernst Friedman, Jacox, Kerr, Leucutia, Pendergrass, Quick, Trump and Widman, to name only a few of the 53 co-authors, have international reputations.

The wide range of the use of roentgen- and radium-rays as well as radioactive isotopes is presented in 36 chapters. The physical and pathological aspects of radiation therapy have been limited to the extent necessary to elucidate the clinical text. In some books written by a group of authors the advantage of a pooled knowledge of experts is more than offset by unevenness in quality of presentation and space distribution. These disadvantages have been held to a minimum in Portmann's book. It is therefore difficult to pick out special authors and their chapters without doing justice to other authors. However, in order to give some idea of the wide scope of the book a few chapters may be selected. Kerr on the treatment for diseases of the nervous system, Blady on diseases of the naso-accessory sinuses, Harris, et al., on radiation therapy for cancer of the larynx, Jacox on the treatment of diseases of the kidney and adrenal gland, Friedman on tumors of the testis and their treatment, Ernst, on intracavitary radium for cancer of the cervix, Leucutia on the treatment of diseases of the skeletal system, joints and soft tissues, and a practical and useful chapter by Quick on the care of patients receiving radiation therapy.

The book is well printed and illustrated. It is without doubt the best and most comprehensive text on therapeutic radiology which has been published so far. It belongs in the library of every radiologist and every physician and surgeon interested in radiological therapy.

TRENDS IN GERONTOLOGY. By *Nathan W. Shock*, Chief, Section on Gerontology, National Heart Institute, National Institute of Health and the Baltimore City Hospitals. Cloth. Price, $2.50. Pp. 153 with diagrams. Stanford University Press, Stanford, California, 1951.

This work is the outcome of the survey sponsored by the Forest Park Foundation of Peoria, Ill., to study the field of gerontology. The selection of Doctor Shock for this work was a most fortunate one — he has had much experience so that his analysis of the needs and his recommendations for their solution are to be seriously considered. In addition to surveying the literature, he made visits to old folks homes, housing projects, recreation clubs, institutes, community and other organizations for the aged.

The chapters discuss the trends in medical management, community activities, education, housing, recreation and rehabilitation of the aged. "He appraises the current research and offers an extensive program for creating a national institute of gerontology for expanding our knowledge of our aging population."

Complete and carefully scaled graphs and charts accompany the text to show more clearly how geography, housing facilities, employment conditions and health programs affect life-expectancy at decennial ages, assuming elimination of specific causes of death.

PHYSICAL MEDICINE ABSTRACTS

Water as a Medium for Therapeutic Exercise. Robert L. Bennett.

New York State J. Med. 51:513 (Feb. 15) 1951.

No new development in the use of water as a medium for therapeutic exercises is included in this discussion. Instead, it is intended to discuss the use of the therapeutic pool to illustrate the role of this phase of hydrotherapy in both the specialized and the general practice of physical medicine. The discussion will be of value if it does nothing more than point out to those who know little of this phase of medicine that the therapeutic pool is not a swimming pool. These two types of pools have the same relationship to each other in usage as does specific muscle reeducation in the convalescent stage of poliomyelitis to the general body calisthenics in athletic training.

As in all types of muscle reeducation, the results of hydrotherapy will depend upon the physical therapist. The physical therapist must not only be thoroughly trained in muscle reeducation procedures but must have additional and specific training in the use of water as an exercise medium. There is the tendency, even among medical men, to believe any swimming instructor is capable of treating a patient adequately in water. Nothing could be more dangerous. It must be emphasized that the basic principles of therapeutic exercise and specific muscle reeducation are the same in water as out of water. The physical therapist must actually have more training to use water than other mediums of exercise, but the advantages to the patient and the results obtained are worth it.

Rapid Rehabilitation of Disabilities of the Knee. Donald L. Rose, and Lilyan G. Warner.

J. Kansas M. Soc. 52:49 (Feb.) 1951.

Eighty-two patients with the common complaint of pain in and instability of the knee were subjected to progressive resistance exercise of the quadriceps.

Each exercise period was preceded by immersion of the extremity in the whirlpool bath for 20 minutes at a water temperature of 105 degrees. This was done not only for the purpose of providing the active hyperemia necessary for the exercises to follow, but also to facilitate relaxation from any muscle tightness or spasm that might be present.

The exercises proper were carried out according to a rather rigid routine. All patients received the same general instructions as follows:

(1) Never begin exercise with heavy weights. Start with light weights and increase.

(2) Raise and lower the weights slowly at the same rate of speed.

(3) Avoid sudden jerky motions.

(4) Practice complete flexion and extension with each contraction.

(5) Pause between contractions and momentarily relax the muscle.

(6) Concentrate on the muscle being exercised.

(7) Never do more than 10 contractions with one weight.

(8) Total number of contractions for any one exercise period should be between 40 and 80.

(9) Exercise only five days a week.

(10) Exert the maximum effort once a week.

Of the 82 patients, 56 patients (71 per cent) achieved clinical remission by this method. Twenty-three patients (28 per cent) were improved. Three patients (4 per cent) were unimproved and two of this group ultimately were operated on with removal of a fractured meniscus. The large majority of the patients were college age adults, older patients included in the series responded healthy except for the knee disability. The few older patients included in the series responded as well to the procedure as did the younger group. The effect of cross education was repeatedly noted throughout the exercise series. The exercise program, although rigid in its employment, was easy to incorporate into the daily activities of the patient and necessitated only the keeping of accurate records and the willingness to engage in a treatment procedure which covers a reasonably long period of time.

Fibrositis. James Mennell.

M. Press 5831:130 (Feb. 7) 1951.

The treatment of fibrositis consists of proper diet, the use of heat, cold and massage.

Heat is among the most popular of remedies, and is safest and best when produced by conducted heat, particularly when it can be provided with an element of support in the form of a hot-water bottle, heated sand-bag or kaolin poultice. Radiant heat, either from an ordinary incandescent lamp or from an infra-red lamp, is often of service. Any remedy requires proper dosage and an overdose frequently does more harm than good.

The technique of application is important, and it is best administered by spraying the affected area with ethyl chloride from a considerable distance. This process is continued till the first sign of blanching appears, at which time the spraying should cease and the whole area should be rubbed lightly with a warm hand. This process should be continued three times and no more. One precaution is essential, namely, that there is always

a tendency for the minute drops from the spray to coalesce and to trickle down the surface of the skin in a small stream. Rubbing the surface with a warm hand, should it occur is all that is required to prevent burning.

Next to the prescription of heat, that of massage has been perhaps the second most common remedy prescribed when fibrositis has been suspected. Unfortunately, like so many other good things, abuse of the treatment is common, mainly because it is not made clear to the physical therapist what the objective may be. It also is unfortunate that so many people pin their faith upon one form of massage, to the exclusion of all others. This has been due largely to confusion of thought among prescribers. There still are many patients who feel that they are not "getting their money's worth," unless massage causes pain and discomfort and many physical therapists labor under the same delusion. Also, one must consider what may be the pathological cause of sensitive nodules and masses that can so often be felt, and which so often disappear, temporarily, as the result of deep massage.

Modern Concepts of Diathermy. Jerome Weiss.

New York State J. Med. **51**:506 (Feb. 15) 1951

Until very recently diathermy has been considered to be limited to the application of high frequency currents to the body to produce heat in the tissues. This afforded a method of conversive heating of an area by the change in the tissues of electrical energy to heat. The application of diathermy has now been broadened by the introduction of microwave diathermy, which utilizes a light wave, and the ultrasonic generator, which employs a sound wave, to produce similar conversive heating of the tissues.

Weiss gives a review of what has been learned in a half century of the application of the older forms of diathermy, the prospects for the use of the newer forms, and the problems imposed by legal rectification of the frequencies employed.

Experience with Ligation and Heparin in Thromboembolic Disease. I. S. Ravdin, and Charles K. Kirby.

Surg. **29**:334 (March) 1951.

Despite efforts to reduce their incidence, thromboembolic complications occurred in approximately 1 per cent of 27,802 postoperative patients during the five year period from January 1, 1945, to December 31, 1949. Phlebothrombosis and thrombophlebitis occurred in 0.65 per cent, nonfatal pulmonary infarction in 0.205 per cent, and fatal pulmonary embolism in 0.11 per cent of these patients.

Since reliance was placed on early and continued exercise in bed and on early ambulation as prophylactic measures, the actual amount of activity of the thirty-one patients in the fatal embolism group was carefully studied. Nineteen of the patients had not been out of bed following operation. The majority of these were too ill to do active and continued bed exercises, or often even to move themselves in bed. Six patients were hypoactive, both in and out of bed. The remaining six satisfied all of the exercise criteria and had been actively ambulating. Elastic bandages to the lower extremities also were used, and the use of proximal vein ligation and anticoagulants was individualized. Instances of failure despite the use of these measures have been discussed.

It is probable that the incidence of fatal pulmonary embolism can be reduced only by effective mass prophylaxis, by a clearer understanding of the important etiologic factors causing venous thrombosis, or by the development of tests which indicate incipient thrombosis so that some type of effective therapy can be instituted.

Acute Massive Venous Occlusion of the Lower Extremities. J. Ross Veal; Thomas J. Dugan; William L. Jamison, and Richard S. Bauersfeld.

Surg. **29**:355 (March) 1951.

Acute massive venous occlusion of a lower extremity may result from extensive thrombosis, sudden plugging of the major veins of the pelvis and thigh by a shifting thrombus, or by ligation of the main venous channel. There almost always remain some patent venous channels in the extremities regardless of the type of obstruction. These channels can be made to empty large quantities of blood from the extremities. Sympathetic nerve blocks, although performed early in nine cases, failed to give relief of symptoms. Another nine cases all responded to elevation of the limb and exercise, which relieved the venous engorgement. The method is simple and safe even in a case in which a shifting thrombosis had caused the occlusion. The involved extremity has been elevated quite high, from 60 to 75 degree angles. Then the foot has been extended and flexed rapidly. These movements contract and relax the various muscles of the leg and massage the blood upward in the patent veins. At the same time the thigh is flexed and extended. This contracts and relaxes the thigh muscles and expresses the venous blood forward into the veins of the groin and lower abdomen. When the venous engorgement has been reduced, fresh arterial blood can then enter the vascular bed. As soon as the blood once again begins to flow through the extremity the acute symptoms disappear. The pain rapidly subsides, the cyanosis gradually disappears, the veins show less distention and the skin temperature becomes elevated. The exercise should be continued with short intervals of rest until the limb can be allowed to remain at a high level on pillows without showing a return of venous engorgement. When this much improvement has been achieved the patient usually can maintain it by actively going through these movements at regular intervals throughout each day. Elevation of the extremities is maintained until all swelling has subsided, and then dependency and activity

is gradually allowed. All patients were fitted with elastic stockings and are instructed to wear them as long as the edema persists.

Rehabilitation in Urological Surgery. Frank O'Gorman.

Brit. J. Phys. Med. 14:37 (Feb.) 1951.

Following urological operations, respiratory exercises are carried out, beginning in many cases on the same day. Active bed exercises are practiced from the first postoperative day under the supervision of the physical therapist. Gentle massage and stroking movements assist the circulation, particularly in elderly patients, but must never replace active movements. Early ambulation is of vital importance where permitted by the general condition and nature of the operation, especially in the aged. It is now proved that the greatest prophylactic against pulmonary embolus is early active movement and ambulation.

It must be realized that surgical operation constitutes only one item in the rehabilitation program. Together with physical medicine and its application in therapy, with occupational therapy, psychosocial adjustment and vocational retraining, it plays its part in the combined effort to restore each patient to the fullest possible life compatible with his ailment and disability. In no branch of medicine or surgery can rehabilitation achieve more conspicuous success than in urology.

Management of the Ambulant Arthritic Patient. Arthur M. Pruce.

J. M. A. Georgia 40:101 (March) 1951.

An effective program must offer simple, readily available and inexpensive measures.

In treating an arthritic hand, the author suggests the injection of novocain for fibrositis, with hot paraffin dips and local massage as supplementary measures. When rheumatoid arthritis of the hand is active and progressive, splinting in a functional position usually will relieve pain, cause muscle spasm to subside and permit early motion. After removal of the splint, hot paraffin packs are effective in overcoming residual muscle spasm and pain, as well as improving circulation. In chronic degenerative joint disease involving the fingers, ethyl chloride spraying of these areas during acute pain has produced a satisfactory analgesia. The patient is taught how to self-spray to the point of cooling with precaution against freezing the area. When acute inflammation has subsided, hot paraffin packs are useful.

Cervical arthritis with or without nerve root pain is very common, and the most important tool in its management is neck traction with a halter. Traction, to be effective, must separate spinal segments, which can be accomplished by the use of a head halter and adequate weights. This is followed by diathermy and massage. These measures are supplemented by a traction program at home, the prescribed program varying according to such factors as the patient's symptoms and response. Symptomatic treatment includes hot wet packs and sedatives through the acute stage. As pain subsides, cautious active motion to restore a functional range is introduced.

Degenerative joint disease or osteo-arthritis probably is the most common pathology associated with backache in the older patient. The shortened lumbar muscles are treated with diathermy and deep massage. With relaxation of the contractured spinal muscles, exercises for the atonic abdominal and gluteal muscles are prescribed. For back muscles in painfully acute spasm, an adequate corset support is far superior to adhesive strapping.

In the lower extremity, the knee joint is the most often involved, the most often seen. In the acute phase, short periods of bed rest are superior to crutches. Usually the treatment of painful knee consists of the readily available application of heat. Unfortunately, the misuse of heat is a common occurrence. It is a mistake to apply the heat to the anterior aspect of the knee, although it is true that "baking" will have a local and transitory analgesic effect. Excessive "baking" of a swollen knee will engender a chronic passive congestion, thereby aggravating local disease. Diathermy of the knee here is contraindicated.

Multiple Sclerosis—Its Diagnosis and Treatment. A. B. Baker.

Wisconsin M. J. 50:245 (March) 1951.

Multiple sclerosis is a fairly common chronic disease of the nervous system of undetermined etiology. It is a disease of the younger age group, over 75 per cent of the patients being between the ages of 20 and 40 years. Because of the variable nature of this disease, it is extremely difficult to describe the clinical features of this illness, since rarely are two cases similar. In spite of the fact that there is, at present, no specific treatment for multiple sclerosis, the physician actually finds himself in no different position than he does in many other medical diseases. Physical therapy is of utmost importance in the treatment of multiple sclerosis. It is not aimed at altering the pathology or the course of the illness but merely to direct the patient as to how to handle himself in spite of his disabilities and to use his residual capacities to the fullest extent.

Immobilization should be avoided in this disease. The patient should be encouraged to be active in spite of his limitations. Inactivity on the part of these patients will greatly increase their limitations and will hasten complications, such as pneumonia, bed sores, contractures, and so forth. On the other hand, the activity of the patient never should proceed to a point of physical exhaustion. These patients must be guided to maintain their activity within their capabilities. Specific physical therapy procedures can be aimed at strengthening the remaining musculature, training other intact muscles to perform substitute movements for involved musculature and the application of such devices as braces, crutches, and

so forth, to help compensate for the various disabilities.

Although there is no specific treatment for this disease, the patient should be treated symptomatically and should be taught to adjust to his disabilities. Stress situations should be avoided in multiple sclerosis, since they tend to aggravate the course of the illness.

National Program in Rehabilitation Must Be Expanded. Frank H. Krusen.

Minnesota Med. **34**:47 (Jan.) 1951.

Physical medicine and rehabilitation are combined today to include the employment of physical therapy,occupational therapy, psychosocial adjustment and vocational training in an attempt to achieve maximal function and adjustment of the handicapped or disabled individual and to prepare him physically, mentally, socially and vocationally for the fullest possible life compatible with his abilities and disabilities. Our national leaders have urged extension of rehabilitation programs. The investment in rehabilitation is an investment in the greatest and most valuable of our possessions, the conservation of human resources. This was the opinion of Bernard M. Baruch when he founded the Baruch Committee on Physical Medicine in 1944. If our nation is to be successful in providing adequate facilities for restoration of all our disabled citizens we must double, redouble, and redouble again our pioneering, voluntary programs to provide service to the handicapped; train personnel to care for the disabled; and provide medical research in methods of restoration following disease or injury.

Trends in the Management of Cerebral Palsy. F. A. Hellebrandt.

Virginia M. Monthly **78**:20 (Jan.) 1951.

Increased interest in the rehabilitation of the chronically disabled is influencing attitudes toward the cerebral palsied.

The first step in the organization of a State program for the cerebral palsied is case finding and registration. Once the status of the patient has been evaluated, a long-term treatment program can be planned. At the outset, general health and seizure control take precedence over all other considerations. Adequate bracing is probably second in importance. Bracing has two functions in the management of the cerebral palsied; first, the prevention of deformities, and second, the selective control of movement patterns during the period of functional training.

The experience of recent years indicates that optimal results are obtained when a progressive program of physical therapy is integrated with an appropriately modified program of education, including speech therapy.

Carefully taught home treatment programs coupled with homebound education provide a substitute to meet the needs of communities in which modern physical medicine and rehabilitation facilities are as yet unavailable. To be effective these must either be supervised by itinerant field workers trained in the techniques of treating the cerebral palsied, or the patient must be returned to field clinics or the outpatient clinic of the diagnostic center sufficiently often to permit adequate follow-up evaluation and guidance.

The nature of program for the cerebral palsied now developing in various parts of the country differs with the exigencies of regional and local limitations. Private agencies like the National Society for Crippled Children and Handicapped Adults and its affiliated State Societies have made a notable contribution by supporting the postgraduate specialty training of physicians and their technical assistants, providing direct services to the disabled in demonstration centers, and by sponsoring vigorous programs of both lay and professional education in the form of publications, scientific exhibits, symposia and lectures.

Fifty Years of Progress of Physical Medicine and Rehabilitation in New York State. Samuel S. Sverdlik; Donald Covalt, and Howard A. Rusk.

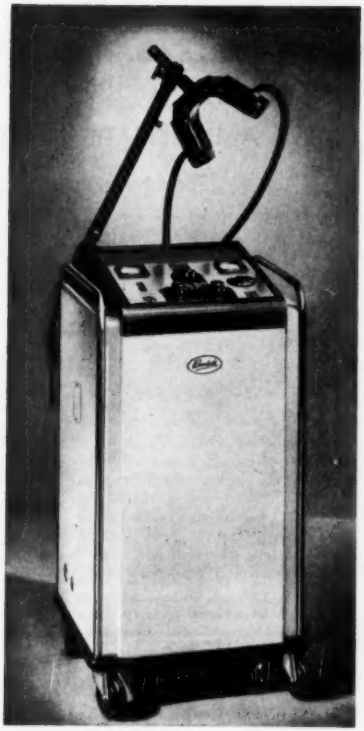
New York State J. Med. **51**:90 (Jan.) 1951.

There have been dramatic changes in the medical and social scene in the past fifty years. Prior to World War I the major concern of the community with relation to the disabled was with the crippled child. During World War II physical medicine and rehabilitation received its greatest impetus. Although it is one of the oldest therapeutic modalities known to medicine, physical medicine and rehabilitation is the newest medical specialty recognized by the Council of Medical Education and Hospitals of the American Medical Association. Due to the increasing knowledge of electronics and biophysics, a more comprehensive understanding of the biologic and biochemical principles involved in the pathologic processes, and the physiologic and vocational problems of the disabled and chronically ill, this specialty has made more rapid strides in the past decade than in all time hertofore.

Orthopedic Aspects of Backache. Richard H. Kiene.

Indust. Med. & Surg. **20**:19 (Jan.) 1951.

The most common cause of the backache seen by the orthopedist is posture, which may or may not be associated with definite organic change. These patients are improved by postural exercises, by general improvement of their physical conditions and, if the patient is a woman, by proper corseting. There is no substitute for a complete history, a thorough and intelligent physical examination, and appropriate, adequate x-ray studies. With these as a basis, satisfactory treatment will follow.



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MEETINGS OF INTEREST
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FIELD OF PHYSICAL MEDICINE AND REHABILITATION

In this column will be published information about meetings of interest to those in the field of physical medicine. New data should be sent promptly to the office of the ARCHIVES, 30 North Michigan Avenue, Chicago 2, Illinois.

American Congress of Physical Medicine. — 29th Annual Session, Shirley-Savoy Hotel, Denver, Colo., Sept. 4, 5, 6, 7, 8, 1951. Walter J. Zeiter, M.D., Chairman, Convention Committee, 30 North Michigan Ave., Chicago 2.

Section on Physical Medicine and Rehabilitation of the American Medical Association. — Wednesday, Thursday and Friday morning of the A.M.A. meeting (June 11-15, 1951) in Atlantic City. Secretary, Walter J. Zeiter, M.D., Cleveland Clinic Foundation, 2020 E. 93rd Street, Cleveland 6, Ohio. *See announcement, elsewhere, this issue.*

New Jersey Society of Physical Medicine. — Meetings, fourth Wednesday. James C. Hanrahan, M.D., Secretary, 678 N. Broad St., Elizabeth 3, N. J.

New York Society of Physical Medicine. — Meetings, first Wednesday. Madge C. L. McGuinness, M.D., Secretary, 48 E. 62nd St., New York 21, N. Y.

Pennsylvania Academy of Physical Medicine. — Meetings, third Thursday. Charles Furey, Jr., M.D., Secretary, 2501 S. Cleveland Avenue, Philadelphia 45, Pa.

The National Society for Crippled Children and Adults, Inc. — 1951 annual convention, Palmer House, Chicago, October 3, 4, 5 and 6, 1951. Lawrence J. Linck, Executive Director, 11 So. La Salle St., Chicago 3.

American Physical Therapy Association. — Glenwood Springs, Colo., Hotel Colorado, June 17-22, 1951. Mildred Elson, Executive Director, 1790 Broadway, New York 19, N. Y.

American Occupational Therapy Association. — Annual Convention, Sept. 8 to 15, Durham, N. H., Wentworth-by-the-Sea Hotel. Co-chairmen, Eleanora Chernewski, VA Hospital, Togus, Maine, and Margaret L. Blodgett, U. S. Marine Hospital, Brighton, Mass.

International

International Congress of Physical Medicine (1952). London, July 14 to 19, 1952. Applications for the provisional program should be addressed to the Honorary Secretary, Dr. A. C. Boyle, International Congress of Physical Medicine (1952) 45, Lincoln's Inn Fields, London, W.C. 2.

European Congress on Rheumatism — Barcelona, Spain, Sept. 24-27, 1951. Dr. Gunnar Edstrom, Lund, Sweden, Secretary.

International Gerontological Congress. — Hotel Jefferson, St. Louis, Mo., U. S. A., Sept. 9-14, 1951. Dr. John E. Kirk, 5600 Arsenal Street, St. Louis 9, Mo., Chairman, Program Committee.

International Poliomyelitis Congress. — Copenhagen, Denmark, Sept. 2-7, 1951. Prof. Niels Bohr, Statens Seruminstitut, 80 Amager Blvd., Copenhagen S., Denmark, President.

International Society for the Welfare of Cripples. — Fifth World Congress, Stockholm, Sweden, Sept. 10-14, 1951. Mr. Donald V. Wilson, 54 E. 64th St., New York 21, N. Y., U. S. A., Executive Director.

World Confederation for Physical Therapy. — Sept. 7 and 8, 1951, Copenhagen. Further information may be obtained from Miss M. J. Neilson, Convener and Secretary, Provisional Committee, World Confederation for Physical Therapy, Tavistock House North, Tavistock Square, London W. C. 1, England.

Tenth International Congress of Industrial Medicine. — Lisbon, Portugal, Sept. 9th to 15th, 1951. Secretary, Prof. L. Carrozzi, Instituto Nacional do Trabalho e Previdência, Praça do Comércio, Lisbon.

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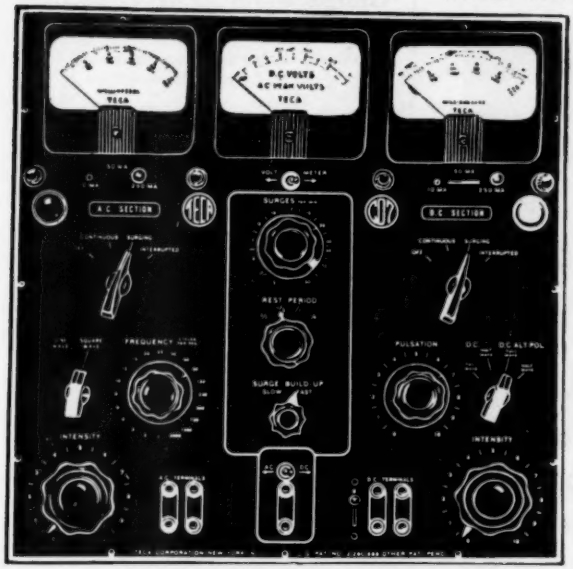

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